8.0 POLLUTION PREVENTION PRACTICES AND WASTEWATER TREATMENT TECHNOLOGIES

In general, MP&M facilities generate process wastewater containing metals, cyanide, oil and grease, and suspended solids. Pollution prevention practices and wastewater treatment technologies currently used by facilities evaluated for the final rule ("MP&M facilities") are designed to remove these pollutants before they are discharged to either a receiving stream (direct discharge) or public owned treatment works (indirect discharge). The type of pollution prevention practice and wastewater treatment technology a MP&M facility selects depends on the manufacturing operations generating the wastewater. Many facilities have implemented process modifications for waste reduction. Some of those modifications include prolonging process bath life by removing contaminants, redesigning part racks to reduce dragout, installing spray or fog nozzle rinse systems, and installing dragout recovery tanks (1).

Most MP&M facilities rely on chemical precipitation and gravity or membrane clarification to remove metals; however, certain pretreatment techniques may be necessary when chelated metals or hexavalent chromium are present. Facilities that generate oily wastewater from operations such as machining and grinding typically use chemical emulsion breaking followed by gravity or membrane clarification. If cyanide is present, facilities typically use oxidation techniques such as alkaline chlorination.

This section describes the pollution prevention practices and wastewater treatment technologies that are used by MP&M facilities, in the first instance, to prevent the generation of wastewater pollutants or, secondarily, to reduce the discharge of wastewater pollutants. Section 8.1 describes flow reduction practices, Section 8.2 describes in-process pollution prevention technologies, Section 8.3 describes management practices for pollution prevention, Section 8.4 describes technologies used for the preliminary treatment of waste streams, and Section 8.5 describes end-of-pipe wastewater treatment and sludge dewatering technologies. This section discusses the most prevalent treatment technologies, as determined by survey responses and site visits, in place at facilities evaluated for the final rule. This section includes descriptions of all the technologies evaluated for the final rule and used as a basis for the MP&M effluent guidelines (see Section 9.0). Additional technologies may be applicable for some MP&M facilities, depending on the waste streams generated. Additionally, not all technologies discussed in this section are applicable to all MP&M facilities; the applicability of a technology is driven by the unit operations performed and waste streams generated on-site. EPA presents pollution prevention practices and wastewater treatment information potentially applicable to all facilities evaluated for the final rule ("MP&M facilities").

8.1 Flow Reduction Practices

MP&M facilities applies flow reduction practices to process baths or rinses to reduce the volume of wastewater discharged. Flow reduction practices consist of optimizing rinse tank design and configuration, and installing flow reduction technologies such as flow restrictors or timers. Table 8-1 lists various flow reduction practices and the number

observations at EPA MP&M site visits and surveys (see Section 3.0). This table also provides EPA's estimate of the number of MP&M facilities employing the various flow reduction practices based on occurrence at surveyed facilities and their respective survey weights. The following subsections discuss these flow reduction practices in greater detail.

8.1.1   Rinse Tank Design and Innovative Configurations

Rinsing follows many proposed MP&M operations[1] to remove dirt, oil, or chemicals remaining on parts or racks from a previous unit operation (i.e., drag-out). Rinsing improves the quality of the surface finishing process and prevents the contamination of subsequent process baths. Rinse tank design and rinsing configuration greatly influence water usage. The key objectives of optimal rinse tank design are to quickly remove drag-out solution from the part and to disperse the drag-out throughout the rinse tank.
MP&M facilities uses various rinsing configurations. The most common are countercurrent cascade rinsing, drag-out rinsing, and spray rinsing. EPA estimates that over 5,000 MP&M facilities use at least one of these rinse schemes to reduce wastewater flow. The use of single overflow rinse tanks following each process tank is the most inefficient use of rinse water. Multiple rinse tanks connected in series (i.e., cascade rinsing) reduce the water needs of a given rinsing operation by one or more orders of magnitude (i.e., less water is needed to achieve the same rinsing quality). Spray rinsing, where the part is suspended over a tank and rinsed with water applied by spray nozzles, also may be used to reduce water use requirements, although less than countercurrent cascade rinses. Below are descriptions of some of the common rinse types.

Cascade Rinsing

Cascade rinsing is a method of reusing water from one rinsing operation to another, less critical rinsing operation before being discharged to treatment. Some rinse waters acquire chemical properties, such as low pH, that make them desirable for reuse in other rinse systems. For example, water from an acid treatment rinse may be reused in an alkaline treatment rinse. In this case, the rinse water both removes drag-out from the work piece and neutralizes the drag-out.

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[1]Note: EPA evaluated a number of unit operations for the May 1995 proposal, January 2001 proposal, and June 2002 NODA (see Tables 4-3 and 4-4). However, EPA selected a subset of these unit operations for regulation in the final rule (see Section 1.0). For this Section, the term "proposed MP&M operations" means those operations evaluated for the two proposals, NODA, and final rule. The term "final MP&M operations" means those operations defined as "oily operations" (see Section 1.0, 40 CFR 438.2(f), and Appendix B to Part 438) and regulated by the final rule.

Table 8-1

MP&M Flow Reduction Technologies

Technology	Technology Description	Demonstration Status		
		Number of Facilities Visited Using the Technology[a]	Number of Survey Facilities Using the Technology[b]	Estimated Number of MP&M Facilities Using the Technology[c]
Countercurrent Cascade Rinsing	Series of consecutive rinse tanks that are plumbed to cause water to flow from one tank to another in the direction opposite of the work flow. Water is introduced into the last tank of the series, making it the cleanest, and is discharged from the first tank, which has the highest concentration of pollutants.	110	130	1,569
Drag-Out Rinsing	Stagnant rinse, initially of fresh water, positioned immediately after process tanks. The drag-out rinse collects most of the drag-out from the process tank, preventing it from entering the subsequent flowing rinses. Drag-out rinse is commonly reused as make-up for heated process bath to replace evaporative loss.	62	139	1,737
Spray Rinsing	Water sprayed on parts above a process tank or drip/drag-out tank; uses considerably less water than immersion for certain part configurations. This technology can also be performed as countercurrent cascade rinsing with spray rinses instead of overflow immersion rinses.	75	187	1,767
Flow Restrictors	Equipment that prevents the flow in a pipe from exceeding a predetermined flow rate. Flow restrictors can be used to limit the flow into a rinse system. For continuously flowing rinses, a flow restrictor controls the flow into the system, ensuring a consistent, optimum flow rate.	50	127	1,581

Table 8-1 (Continued)

Technology	Technology Description	Demonstration Status		
		Number of Facilities Visited Using the Technology[a]	Number of Survey Facilities Using the Technology[b]	Estimated Number of MP&M Facilities Using the Technology[c]
Conductivity Probes	Equipment that measures the conductivity of water in a rinse tank to regulate the flow of fresh rinse water into the rinse system. A solenoid valve on the rinse system fresh water supply is connected to the controller, which opens the valve when a preset conductivity level is exceeded and closes the valve when conductivity is below that level.	40	29	320

Source: MP&M site visits, MP&M sampling episodes, MP&M surveys and technical literature. Statistics specific to wastewater-discharging facilities.

[a]Indicates the number of MP&M facilities visited by EPA that use the listed technology. EPA visited a total of 221 facilities.

[b]Number of survey facilities based on data collected in 1996 detailed survey only. The 1989 survey did not request this information. EPA sent the 1996 detailed survey to 311 facilities.

[c]Indicates the estimated number of MP&M facilities currently performing this technology based on the 1996 detailed survey. EPA's national estimate of the 1996 detailed survey includes approximately 4,900 facilities. EPA estimated numbers in this column using statistical weighting factors for the 1996 detailed survey respondents. See Section 3.0 for a discussion of the development of national estimates and statistical survey weights.

Countercurrent Cascade Rinsing

Countercurrent cascade rinsing refers to a series of consecutive rinse tanks that are plumbed to cause water to flow from one tank to another in the direction opposite of the work flow. Fresh water flows into the rinse tank located farthest from the process tank and overflows (i.e., cascades) into the rinse tank that is closest to the process tank. This is called countercurrent rinsing because the work piece and the rinse water move in opposite directions. Over time, the first rinse becomes contaminated with drag-out solutions and reaches a stable concentration of process bath constituents that is lower than the concentration in the process bath. The second rinse stabilizes at a lower concentration, which enables less rinse water to be used than if only one rinse tank were in place. The more countercurrent cascade rinse tanks (three-stage, four-stage, etc.), the less rinse water is needed to adequately remove the process solution. This differs from a single, overflow rinse tank where the rinse water is composed of fresh water that is discharged after use without any recycle or reuse. Figure 8-1 illustrates countercurrent cascade rinsing.
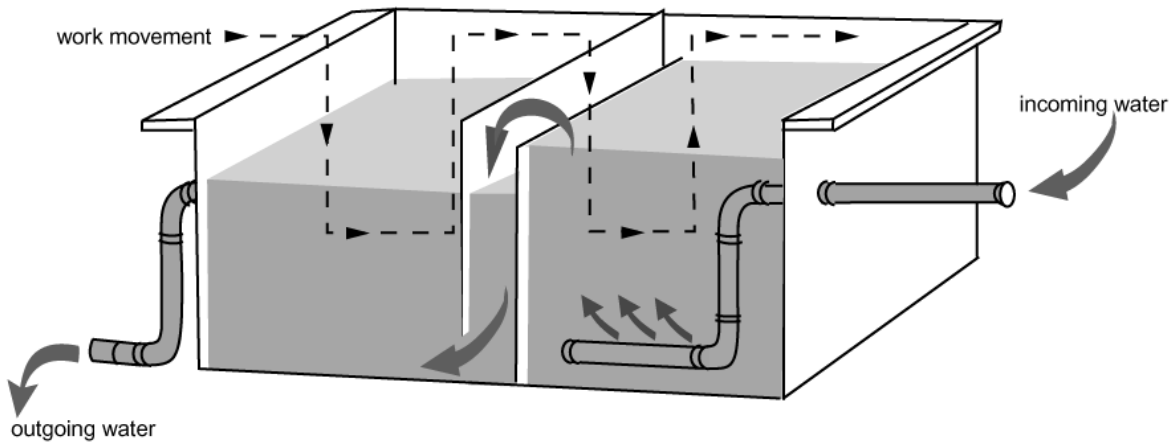

Figure 8-1. Countercurrent Cascade Rinsing

The rinse rate needed to adequately dilute drag-out depends on the concentration of process chemicals in the initial process bath, the concentration of chemicals that can be tolerated in the final rinse tank to meet product specifications, the amount of drag-out solution carried into each rinse stage, and the number of countercurrent cascade rinse tanks. These factors are expressed in Equation 8-1 (2):

$$V_r = \left(\frac{C_o}{C_f} \right)^{1/n} \times V_D \qquad (8\text{-}1)$$

where:

V_r = the flow rate through each rinse stage, gal/min;

C_o = the concentration of the contaminant(s) in the initial process bath, mg/L;

C_f = the tolerable concentration of the contaminant(s) in the final rinse to give acceptable product cleanliness, mg/L;

n = the number of rinse stages used; and

V_D = the drag-out carried into each rinse stage, expressed as a flow rate, gal/min.

This mathematical rinsing model is based on complete rinsing (i.e., removal of all contaminants from the work piece) and complete mixing (i.e., homogeneous rinse water in each rinse stage). Under these conditions, each additional rinse stage can reduce rinse water use by 90 percent. However, each rinse stage needs to have sufficient residence time and agitation for complete mixing to occur in each rinse tank to achieve these conditions. For less efficient rinse systems, each added rinse stage reduces rinse water use by 50 to 75 percent.

Countercurrent cascade rinsing systems have higher capital costs than do overflow rinses and require more space to accommodate the additional rinse tanks. Also, when countercurrent cascade rinsing is used, the low flow rate through the rinse tanks may not provide the needed agitation for drag-out removal. In such cases, air or mechanical agitation may be added to increase rinsing efficiency.

Drag-out Rinsing

Drag-out rinse is a stagnant rinse, initially filled with fresh water, positioned immediately after the process tank. Work pieces are rinsed in drag-out tanks directly after exiting the process bath. The drag-out rinse collects most of the drag-out from the process tank, thus preventing it from entering the subsequent flowing rinses and reducing pollutant loadings in those rinses. Gradually, the concentration of process chemicals in the drag-out tank rises. In the most efficient configuration, a drag-out tank follows a heated process tank that has a moderate to high evaporation rate. A portion of the fluid in the drag-out tank returns to the process tank to replace the evaporative loss. The level of fluid in the drag-out tank is maintained by adding fresh water. Electrolytic recovery, discussed in Section 8.2.6, is commonly used to remove dissolved metals from drag-out tanks.

Spray Rinsing

For certain work piece configurations, spray rinsing uses considerably less water than does immersion rinsing. During spray rinsing, the parts are held over a catch tank and are sprayed with water. Water then drips from the part into the catch tank, and is then either recycled to the next stage or discharged to treatment. Spray rinsing can occur in a countercurrent cascade configuration, further reducing water use. Spray rinsing can enhance draining over a process

bath by diluting and lowering the viscosity of the process fluid film clinging to the work piece. Using spray rinsing can control rinse water flow.

8.1.2   Additional Design Elements

In addition to rinse configuration, unit operations can be modified in other ways to reduce drag-out of process bath chemicals. For example, air knives and drip tanks reduce the pollutant loading and volume of rinse water requiring treatment. Other aspects of good rinse tank design include positioning the water inlet and discharge points of the tank at opposite locations in the tank to avoid short-circuiting, using air agitation for better mixing, using a flow distributor, and using the minimum tank size possible (3). Four rinse design elements are described in more detail below.

Air Knives

Air knives are high-pressure air blowers installed over a process tank or drip shield and are designed to remove drag-out by blowing the liquid off the surface of work pieces and racks and into a catch tank. Liquid from the catch tank is pumped back to the process tank. Air knives are most effective with flat parts and cannot be used to dry surfaces that passivate or stain due to oxidation.

Drip Shields

Drip shields are inclined sheets installed between process tanks and rinse tanks to recover, and drain to the process tank, process fluid that drips from racks and barrels and would otherwise fall into rinse tanks or onto the floor. Often, drip shields are composed of polypropylene or another inert material.

Drip Tanks

Drip tanks are installed immediately after the process tank. Work pieces exiting a process bath are held over the drip tank and the process fluid that drips from the work pieces collects in the drip tank. When enough fluid is collected in the drip tank, the fluid flows back to the process tank.

Long Dwell Time

Automatic finishing lines can be programmed to include optimum drip times. Long dwell times over the process tank reduce the volume of drag-out reaching the rinsing system. On manual lines, racks can be hung on bars over process baths to allow the fluid drip. Barrels can be rotated over the process bath to enhance drainage. Increases in drip time may be unsuitable for surfaces that can be oxidized or stained by exposure to air.

8.1.3   Rinse Water Use Control

Facilities can reduce water use by coordinating and closely monitoring rinse water requirements (e.g., rinse water use is optimized based on drag-out rates so that the rinse quality is consistent). Matching water use to rinse water requirements optimizes the quantity of rinse water used for a given work load and tank arrangement (3). Inadequate controlling water use negates the benefits of using multiple rinse tanks or other water conservation practices and results in a high water usage.

Many facilities use some form of rinse water control. The four most common methods are flow restrictors (these can be used with other methods to regulate the rate at which water is dispensed), manual control (i.e., turning water valves on and off as needed), conductivity controls, and timer rinse controls. Using data from the 1996 MP&M industry survey, EPA estimates there are over 1,900 MP&M facilities using this equipment to control rinse water flow. These are discussed below.

Flow Restrictors

A flow restrictor prevents the flow in a pipe from exceeding a predetermined flow rate. Flow restrictors are commonly installed on a rinse tank's water inlet. These devices contain an elastomer washer that flexes under pressure to maintain a constant water flow regardless of pressure. Flow restrictors can maintain a wide range of flow rates, from less than 0.1 gal/min to more than 10 gal/min. As a stand-alone device, a flow restrictor provides a constant water flow and is therefore best suited for continuous rinsing. For intermittent rinsing operations, a flow restrictor does not coordinate the rinse flow with drag-out introduction. Precise control with intermittent operations typically requires a combination of flow restrictors and rinse timers. However, for continuous rinsing (e.g., continuous electroplating machines), flow restrictors may be adequate for good water use control.

Conductivity Controllers

Conductivity controllers use conductivity probes to measure the conductivity (total dissolved solids (TDS)) of water in a rinse tank to regulate the flow of fresh rinse water into the rinse system. Conductivity controllers consist of a controller, a meter with adjustable set points, a probe that is placed in the rinse tank, and a solenoid valve. As parts are rinsed, dissolved solids enter the water in the rinse tank, raising the conductivity of the water. When conductivity reaches a set point where the water can no longer provide effective rinsing, the solenoid valve opens to allow fresh water to enter the tank. When the conductivity falls below the set point, the valve closes to discontinue the fresh water flow.

In theory, conductivity control of rinse flow is a precise method of maintaining optimum rinsing conditions in intermittent rinsing operations. In practice, conductivity controllers work best with deionized rinse water. Incoming fresh water conductivity may vary day to day and season to season, which forces frequent set point adjustments. In addition,

suspended solids and nonionic contaminants (e.g., oil) can cause inadequate rinsing and are not measured by the conductivity probe.

Rinse Timers

Rinse timers are electronic devices that control a solenoid valve. The timer usually consists of a button that, when pressed, opens the valve for a predetermined time period, usually from 1 to 99 minutes. After the time period has expired, the valve automatically closes. The timer may be activated either manually by the operator or automatically by the action of racks or hoists. Automatic rinse timers are generally preferred for intermittent rinses because they eliminate operator error. Rinse timers installed in conjunction with flow restrictors can provide precise control when the incoming water pressure may rise and fall. Rinse timers are less effective in continuous or nearly continuous rinse operations (e.g., continuous electroplating machines) because the rinse operates nearly continuously.

8.1.4   Pollution Prevention for Process Baths

Facilities also can implement measures that will reduce or prevent pollution in process baths to reduce the drag-out pollutant loadings and therefore the amount of drag-out solution produced. Examples of these technologies are increasing bath temperature, operating at lower batch concentration, and using wetting agents, discussed below:

- Temperature and viscosity are inversely related; therefore, operating a bath at the highest possible temperature will lower process bath viscosity and reduce drag-out.

- Operating at the lowest possible concentration reduces the mass of chemicals in a given volume of drag-out. Also, viscosity and concentration are directly related; therefore, lower process bath concentration will result in lower process bath viscosity and less drag-out volume. Contaminants and other process bath impurities should be minimized, if possible, to extend the usefulness of the bath, reducing the frequency of treatment or disposal.

- Adding wetting agents or surfactants to some process baths reduces viscosity and surface tension, thereby significantly reducing drag-out.

8.2   In-Process Pollution Prevention Technologies

This section describes in-process pollution prevention technologies used at MP&M facilities to reduce pollutant loadings to the wastewater treatment system. Table 8-2 lists a number of in-process pollutant prevention technologies. This table also provides EPA's estimate of the number of MP&M facilities employing the various in-process pollutant

Table 8-2

MP&M In-Process Pollution Prevention Technologies

Technology	Technology Description	Demonstration Status		
		Number of Facilities Visited Using the Technology[a]	Number of Survey Facilities Using the Technology[b]	Estimated Number of MP&M Facilities Using the Technology[c]
Evaporation with Condensate Recovery	Removes water by evaporation, leaving a concentrated residue for disposal and water vapor for condensation and reuse.	7	15	147
Ion Exchange (in-process)	Removes metal salts from electroplating rinse water using combined cation and anion exchange. Effluent (permeate) from the ion exchange flows back to the electroplating rinse system. Ion exchange regenerants are either discharged to the end-of-pipe chemical precipitation unit for metals removal or to electrolytic recovery for metals recovery.	35	33	437
Reverse Osmosis	Forces wastewater through a membrane at high pressure, leaving a concentrated stream of pollutants for disposal. Reverse osmosis may provide an effluent clean enough for reuse.	3	1	3
Centrifugation of Painting Water Curtains	Removes the heavier solids from the water curtain by centrifugation, allowing the water to be reused. The solids are collected as a cake in the basket of the centrifuge. This technology can achieve closed-loop reuse of water curtains.	3	1	12
Filtration of Painting Water Curtains	Removes solids by filtration (cloth, sand, diatomaceous earth, etc.) followed by reuse. This technology can achieve closed-loop reuse of water curtains.	2	3	20
Settling of Painting Water Curtains	Removes the heavier solids from the water curtains by gravity separation. This technology can be used in conjunction with other removal technologies to lessen the solids loading.	5	5	23
Biocide Addition to Lengthen Coolant Life	Can impede the growth of microorganisms that cause rancidity. Machining coolant is often discarded as it becomes rancid.	9	27	216
Centrifugation of Machinery Coolant	Removes the solids from the coolant by centrifugation to extend its usable life. Some high-speed centrifuges can also perform liquid-liquid separation to remove tramp oils and further extend coolant life.	18	10	78

Table 8-2 (Continued)

Technology	Technology Description	Demonstration Status		
		Number of Facilities Visited Using the Technology[a]	Number of Survey Facilities Using the Technology[b]	Estimated Number of MP&M Facilities Using the Technology[c]
Filtration of Machinery Coolant	Removes the solids from the coolant using filters such as cloth, sand, or carbon to extend its usable life.	18	18	142
Skimming of Tramp Oils in Machinery Coolants	Removes tramp oils using mechanical skimming to extend coolant life. Tramp oil buildup often makes machining coolant unusable.	8	9	82
Pasteurization of Machinery Coolants	Kills the microorganisms that cause rancidity using heat. Machining coolant is often discarded as it becomes rancid.	2	2	18
General Filtration of Baths and Solutions	Removes metals and other impurities from process tanks, including electrolytic plating solutions and acid/alkaline cleaning tanks. Increases bath longevity. Technologies include paper filters, carbon adsorption, and magnetic separators.	6		
Electrolytic Recovery (Electrowinning)	Recovers dissolved metals from concentrated sources using an electrochemical process. For rinses, electrolytic recovery is typically restricted to drag-out rinses. Flowing rinses are generally too dilute for efficient electrolytic recovery. This technology effectively recovers metals from ion exchange regenerants.	22	23	142

Source: MP&M site visits, MP&M sampling episodes, MP&M surveys and technical literature. Statistics specific to wastewater-discharging facilities.
[a]Indicates the number of MP&M facilities visited by EPA that use the listed technology. EPA visited a total of 221 facilities.
[b]Number of survey facilities based on data collected in 1996 detailed survey only. The 1989 survey did not request this information. EPA sent the 1996 detailed survey to 311 facilities.
[c]Indicates the estimated number of MP&M facilities currently performing this technology based on the 1996 detailed survey. EPA's national estimate of the 1996 detailed survey includes approximately 4,900 facilities. EPA estimated numbers in this column using statistical weighting factors for the 1996 detailed survey respondents. See Section 3.0 for a discussion of the development of national estimates and statistical survey weights.

prevention technologies based on occurrence at surveyed facilities and their respective survey weights. In-process pollution prevention technologies can be applied to process baths or rinses. Not all technologies discussed in this subsection are applicable to all MP&M facilities.

Process baths become contaminated with impurities that affect their performance. The sources of process bath contamination include: (1) breakdown of process chemicals; (2) buildup of by-products (e.g., carbonates); (3) contamination from impurities in make-up water, chemicals, or anodes; (4) corrosion of parts, racks, tanks, heating coils, etc.; (5) drag-in of chemicals; (6) errors in bath additions; and (7) airborne particles entering the tank. If not properly maintained, process baths become prematurely unusable and require disposal. Regeneration and maintenance techniques help keep baths in good operating condition, thereby extending the useful lives of process solutions. Using these technologies reduces the frequency of process bath discharges, and therefore reduces pollutant loadings to the wastewater treatment system. This, in turn, reduces wastewater treatment requirements and sludge disposal costs.

Rinsing removes residual process chemicals from the surface of a work piece. As more and more work pieces are rinsed, the concentration of process chemicals (contaminants) in the rinse water increases. At some point, the concentration of process chemicals in the rinse water becomes so high that an unacceptable amount of process chemicals remain on the surface of the work piece. When this occurs, clean water is added to the rinse solution to lower the concentration of process chemicals to a level that will not impact the quality of the work piece. Overflow from the rinsing operation goes to treatment for removal of the residual process chemicals. For continuous processing operations, clean water may continuously flow into the rinse process to ensure that the concentration of contaminants will not exceed the quality limit for the work piece.

This section describes the following technologies used to treat and reuse process solutions:

- Activated carbon adsorption;
- Carbonate freezing;
- Centrifugation and pasteurization of machining coolants;
- Centrifugation and recycling of painting water curtains;
- Electrodialysis;
- Electrolytic recovery;
- Evaporation;
- Filtration;
- Ion exchange; and
- Reverse osmosis.

8.2.1 Activated Carbon Adsorption

Activated carbon adsorption is a common method of removing organic contaminants from electroplating baths. Process solution flows through a filter where the carbon

adsorbs organic impurities that result from the breakdown of bath constituents. Carbon adsorption can be either a continuous or batch operation, depending on the site's preference. Carbon treatment is most commonly applied to nickel, copper, zinc, and cadmium electroplating baths but also can be used to remove organic contaminants from paint curtains.

8.2.2   Carbonate "Freezing"

Carbonate "freezing" removes excessive carbonate buildup by forming carbonate salt crystals at a low temperature that are then removed. MP&M facilities most often apply this process to electroplating baths formulated with sodium cyanide. Carbonates build up in the process bath by the breakdown of cyanide (especially at high temperatures) and the adsorption of carbon dioxide from the air. An excessive carbonate concentration reduces the product quality of many metal finishing operations. Carbonate "freezing" takes advantage of the low solubility of carbonate salts in the sodium cyanide bath. The method lowers the bath temperature to approximately 26°F (-3°C), at which point hydrated salt ($Na_2CO_3 \bullet 10H_2O$) crystallizes out of solution. The crystallized carbonate can be removed by decanting the fluid into another tank or by filtration.

8.2.3   Centrifugation and Pasteurization of Machining Coolants

Most machining coolants contain water-soluble oil in water. The water-soluble coolant typically is pumped from a sump, over the machining tool and work piece during machining, and back to the sump. Over a period of time, recycled coolant becomes ineffective, or spent, for one or more of the following reasons:

- The concentration of suspended solids in the coolant begins to inhibit performance;

- Nonemulsified, or "tramp," oil collects on the surface of the coolant, inhibiting performance;

- The coolant becomes rancid due to microbial growth; or

- Coolant additives are consumed by drag-out and organic breakdown, thus reducing corrosion prevention and lubrication properties.

As shown in Table 8-2, EPA estimates that nearly 300 MP&M facilities use centrifugation and biocide/pasteurization processes to extend the life of their water-soluble coolants.

Coolant recycling is most effective when facilities minimize the number of different coolants used on-site and use a centralized coolant recycling system. However, some facilities may not be able to use a single recycling system because of multiple coolant types required by product or customer specifications. In this case, facilities may need to purchase dedicated coolant recycling systems for each type of coolant used.

Using a centrifugal separator and pasteurization unit can extend the useful life of machining coolants. The separator is a rotating chamber that uses centrifugal force to push the coolant through a mesh chamber, leaving behind solid contaminants of sludge. Sludge is scraped from the centrifuge and collected in a sludge hopper. Some high-speed centrifuges also can perform liquid-liquid separation to remove tramp oils. The coolant undergoes pasteurization after separation to kill the microorganisms that cause bacterial growth. Adding a biocide can also control bacterial growth. Figure 8-2 shows a diagram of a typical machine coolant recycling system.
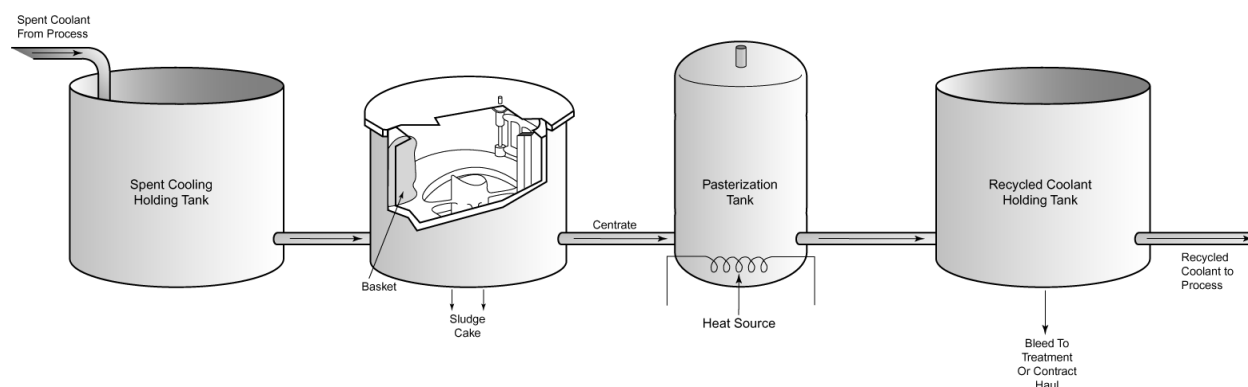

Figure 8-2. Machine Coolant Recycling System

Centrifugal separators are very reliable and require only routine maintenance, such as periodic cleaning and removal of accumulated solids. Flow rate is the primary operating factor to control. The sludge generated from this technology is commonly classified as a hazardous waste, based on the metal type processed and the amount of metal that dissolves into the coolant. Facilities typically haul the sludge off-site for treatment and disposal.

Centrifugation and pasteurization can be used in conjunction with oil skimming and biocide addition to reduce coolant discharge and pollutant generation at the source. Oil skimming using a vertical belt system (described in Section 8.4.5.2) removes large amounts of tramp hydraulic oils floating on the surface of the machine coolant. Oil skimming and biocide addition can further extend the life of water-soluble coolant, thereby reducing the amount of coolant and wastewater requiring treatment and disposal, and minimizing fresh coolant requirements.

8.2.4 Centrifugation and Recycling of Painting Water Curtains

Water curtains are a continuous flow of water behind the work piece being spray painted in a paint booth. The water traps paint overspray and is continuously recirculated in the paint curtain until the solids content in the wastewater necessitates either in-process treatment and recycling or discharge. Based on data from the 1996 MP&M detailed survey, approximately 12 MP&M facilities centrifuge and recycle water from their paint curtains.

Wastewater from painting water curtains commonly contains organic pollutants as well as certain metals. Eliminating the discharge of wastewater from painting water curtains may eliminate the need for an end-of-pipe treatment step for organic pollutants at certain facilities. Moreover, if a facility uses only painting water curtains and continuously recycles the water, the facility would not need end-of-pipe wastewater treatment.

Figure 8-3 shows a diagram of a typical in-process centrifugation and recycling treatment system for a paint curtain. Centrifugal separators remove the solids and recycle the water curtain, eliminating the need for discharge. This system can recycle, the paint curtain water continuously. The system pumps the water curtain from the paint curtain sump to a holding tank, then through the centrifugal separator, which separates the solids from the wastewater (see section 8.2.3). Solids from the centrifuge are hauled for off-site disposal, while the treated wastewater is returned to the paint booth. Centrifugation of the paint curtain proceeds until all wastewater is treated and only sludge remains in the paint curtain sump. Operators must remove the sludge in the paint curtain sump either manually, with a sludge pump, or by vacuum truck. The facility may add detactifiers before centrifugation to increase the solid separation efficiency. Detactifiers make the paint solids less sticky, allowing them to be more easily removed from the centrifuge. Make-up water is added to the system to compensate for evaporation.
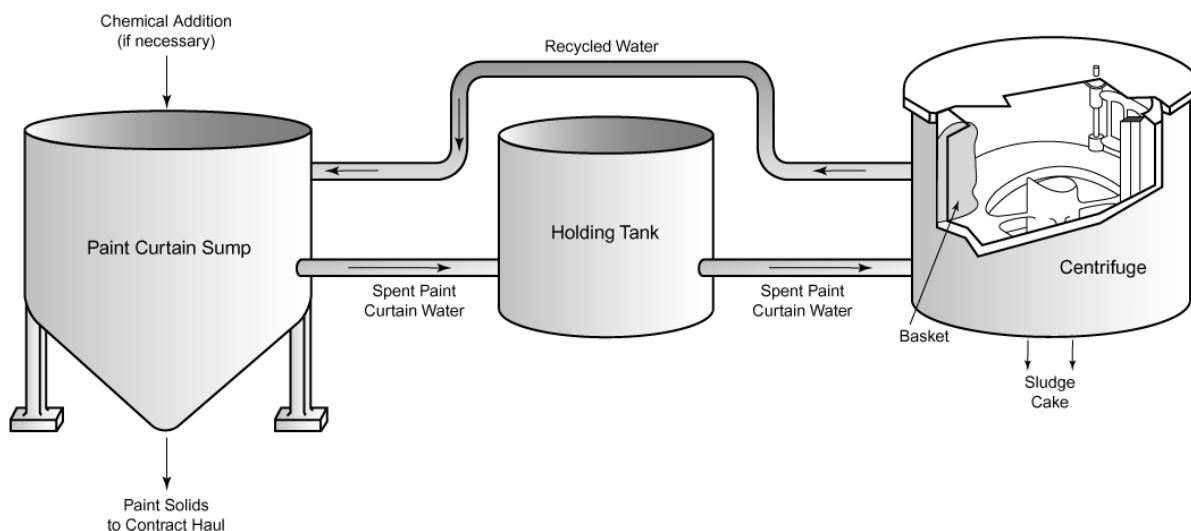

Figure 8-3. Centrifugation and Recycling of Painting Water Curtains

As discussed in Section 8.2.3, centrifugal separators are very reliable and require only routine maintenance. Flow rate is the primary operating factor to control. One disadvantage of this technology is that it may not be economically feasible for facilities generating only a small amount of paint curtain wastewater. Facilities that have multiple sumps can use portable centrifuges.

The sludge generated from painting water curtains is commonly classified as a hazardous waste, based on the type of paint used, and typically is hauled off-site for treatment and disposal. See Appendix D for more information on pollution prevention practices with painting operations.

8.2.5   Electrodialysis

Electrodialysis is a process in which dissolved colloidal species are exchanged between two liquids through selective semipermeable membranes (11). The technology applies a direct current across a series of alternating anion and cation exchange membranes to remove dissolved metal salts and other ionic constituents from solutions.

An electrodialysis unit consists of a rectifier and a membrane stack. The rectifier converts alternating current to direct current. The stack consists of alternating anion- and cation-specific membranes that form compartments. As the feed stream enters the unit, ions move across the electrodialysis membranes, forming a concentrated stream and a deionized stream. When the compartments are filled, a direct current is applied across each membrane in the stack. Cations traverse one cation-specific membrane in the direction of the cathode and are trapped in that concentrate compartment by the next membrane, which is anion-specific. Anions from the neighboring compartment traverse the anion-specific membrane in the direction of the anode, joining the cations, and are likewise trapped in the concentrate compartment by the next cation-specific membrane. In this way, the technology depletes the feed stream of ions, and traps anions and cations in each concentrate compartment. Facilities typically use electrodialysis to remove metal ions from electroplating wastewater. Figure 8-4 shows a diagram of an electrodialysis cell.

EDR Module
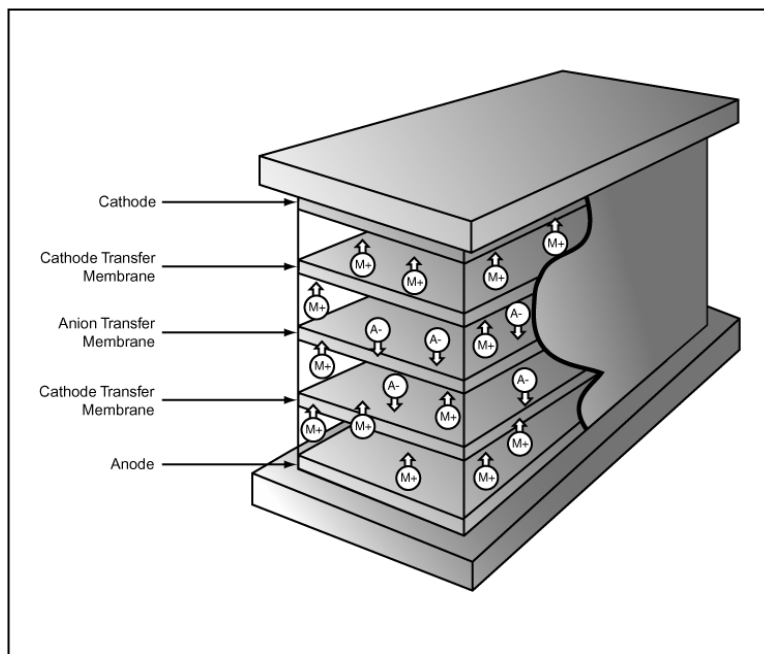
Figure 8-4. Electrodialysis Cell

By using the electrodialysis cell, facilities remove impurities from the process bath, extending its life. Facilities can treat the removed concentrate stream on-site, or haul it off-site for disposal, treatment, or metals reclamation.

8.2.6   Electrolytic Recovery

Electrolytic recovery is an electrochemical process used to recover metal contaminants from many types of process solutions and rinses, such as electroplating rinse waters and baths. Electrolytic recovery removes metal ions from a waste stream by processing the stream in an electrolytic cell, which consists of a closely spaced anode and cathode. Equipment consists of one or more cells, a transfer pump, and a rectifier. Current is applied across the cell and metal cations are deposited on the cathodes. The waste stream is usually recirculated through the cell from a separate tank, such as a drag-out recovery rinse.

Facilities typically apply electrolytic recovery to solutions containing either nickel, copper, precious metals, or cadmium. Chromium cannot be electrolytically recovered because it exists primarily in anionic forms such as dichromate. Drag-out rinses and ion-exchange regenerant are solutions that commonly are processed using electrolytic recovery. Some solutions require pH adjustment prior to electrolytic recovery. Acidic, metal-rich, cation regenerant is an excellent candidate stream for electrolytic recovery and is often electrolytically

recovered without pH adjustment. In some cases, when the target metal concentration is reached, the waste stream can act as cation regenerant.

The capacity of electrolytic recovery equipment depends on the total cathode area and the maximum rated output of the rectifier. Units are available with a cathode area ranging from 1 ft^2 to 100 ft^2 or larger, and an output of 10 to 1,000 amperes or more. Faraday's law, which states the amount of chemical change produced by an electric current is proportional to the quantity of electricity used, determines theoretical electrolytic recovery rates. Theoretical recovery rates range from 1.09 grams/amp-hour for nickel to 7.35 grams/amp-hour for monovalent gold. Actual rates are usually much lower and depend on the metal concentration in the waste stream. At concentrations under 100 mg/L, electrolytic recovery rates may be below 10 percent of the theoretical maximum.

Electrolytic recovery units use various types of cations, depending mainly on the concentration of metal in the waste stream. Cathodes are often classified by their surface area. Flat-plate cathodes have the lowest surface area and are used only for recovering metal from metal-rich waste streams (usually 1,000 to 20,000 mg/L of metal). Reticulate cathodes, which have a metallized woven fiber design, have a surface area 10 times greater than their apparent area. These cathodes are effective over a wide range of metal concentrations but typically are used where the dissolved metal concentration is below 100 mg/L. Carbon and graphite cathodes have the highest surface area per unit of apparent area. Their use is usually restricted to metal concentrations below 1,000 mg/L.

Reticulate or carbon cathodes can recover metals in electrolytes to concentrations as low as 5 mg/L. Electrolytes are substances that dissociate into ions in solution (i.e., water), thereby becoming electrically conducting (4). In practice, however, the target effluent concentration for most applications is 50 to 250 mg/L or higher because of the time and energy required to achieve concentrations less than 100 mg/L. With flat-plate cathodes, the target effluent concentration is usually above 500 mg/L, because plating efficiency drops as concentration falls. Plating time required to lower the concentration of a pollutant from 100 to 10 mg/L can be several times longer than that required to lower the concentration from 10,000 mg/L to 100 mg/L. Also, unit energy costs (measured in dollars per pound of metal recovered) increase substantially at lower metal concentrations.

Electrolytic recovery units have relatively low labor requirements. Units recovering dissolved metal from drag-out rinse tanks only may require occasional cleaning and maintenance. Units treating batch discharges from ion-exchange units (see Section 8.2.8.1) require more labor due to the higher metal content of the solution and the resultant increase in cathode loading frequency. Energy costs for this technology can be high, and, in some cases, exceed the recovery value of the metal. Energy requirements depend on several factors, including required voltage, rectifier efficiency, and current efficiency. In addition, from an energy standpoint, electrolytic recovery removes metals from concentrated solutions more efficiently than from dilute solutions. Electrode replacement costs may be significant for units

using disposable cathodes, especially for high metal recovery rates. However, if electrodes are constructed properly, cathodes and anodes may last more than five years for most applications.

Numerous vendors offer electrolytic recovery technology. The technology is applicable to a wide range of processes, drag-out rinses, and ion-exchange regenerants due to the diversity of materials and configurations available for anodes and cathodes. Electrolytic recovery is not applicable to flowing rinses due to the lower metal concentrations and the extended time required for metal recovery. In most cases, this technology cannot cost-effectively remove dissolved metals to concentrations required for discharge to POTWs or surface waters.

8.2.7   Evaporation

Evaporation is a volume reduction and water recovery technology applicable when raw water costs are high or discharge to either a receiving stream or the local sewerage district is not permitted. EPA estimates there are 147 MP&M facilities using evaporation to reduce the volume of their waste and to recover and reuse their water. Evaporators have the potential to recover 95 percent of the water in a waste stream for reuse in the process. MP&M facilities use two basic types of evaporators: atmospheric and vacuum. Atmospheric evaporators are more prevalent and are relatively inexpensive to purchase and easy to operate. Vacuum evaporators are mechanically more sophisticated and are more energy-efficient. Facilities typically use vacuum evaporators when evaporation rates greater than 50 to 70 gallons per hour are required. MP&M facilities use evaporators to recover metals from ion exchange regenerates, to reduce the volume of oily wastes that require off-site transfer, and to recover and reuse rinse water from plating operations.

Equipment required for evaporation systems include (12):

- Basket strainers in lift stations and sumps to prevent items like shop rags from reaching the evaporator;

- Equalization tanks to handle batch dumps of process water;

- An oil skimmer in the equalization tank to remove floatable oil;

- Evaporators (either vacuum or atmospheric);

- Residue holding tanks;

- Air pollution control equipment;

- A condenser to capture water vapor for return to the manufacturing process; and

- Natural gas or propane tanks for evaporator fuel storage.

Residue from evaporators can be recycled if sufficiently pure, disposed of off-site, or used for energy recovery if the material has a sufficient BTU content.

8.2.8 Filtration

Filtration removes suspended solids from surface finishing operations. EPA estimates there are nearly 150 MP&M facilities that use filters on their machining and grinding operations to remove solids, debris, or swarf from machining coolants. If solids are not removed from machining coolants, they may cause a rough or burred surface on the work piece. Filtered coolants return to the manufacturing process. In-process filtration extends the life of the coolant and reduces the amount of oil and grease sent to treatment. Filtration equipment includes cartridge filters, precoat diatomaceous earth filters, sand, and multimedia filters.

Cartridge filters are available with either in-tank or external configurations. The in-tank units are used mostly for small tanks and the external units for larger tanks. Most cartridges are disposable; however, washable and reusable filters are available, which further reduce waste generation. Precoat, sand, and multimedia filters are used mostly for large tanks. The filter media used depends on the chemical and physical characteristics of the bath, which determine the filter material type, density, nominal micron retention, wet strength, mullen burst, and air permeability. Material type is important to ensure the media is compatible with the liquid being filtered. Media density is how close or dense the media fibers are laid, laminated, or woven. Nominal micron retention indicates the smallest particle size the media will retain to develop a filter cake. Flux rate through the filter is determined by the air permeability characteristics. All filtration systems are sized based on solids loading and the required flow rate.

Membrane filtration also can remove oils and metals from process baths or rinses, and remove solids from paint curtains or tramp oils from machine coolants to extend usable life. They are also commonly used to recover and recycle electrophoretic painting ("e-coat") solutions. Membrane filtration is a pressure-driven process that separates solution components based on molecular size and shape. Solvent and small solutes can pass through the membrane while the membrane retains and collects larger compounds as a concentrated waste stream. The cleaner permeate can be reused in the process while the concentrated waste stream is discharged to treatment. Figure 8-5 shows a typical membrane filtration unit.
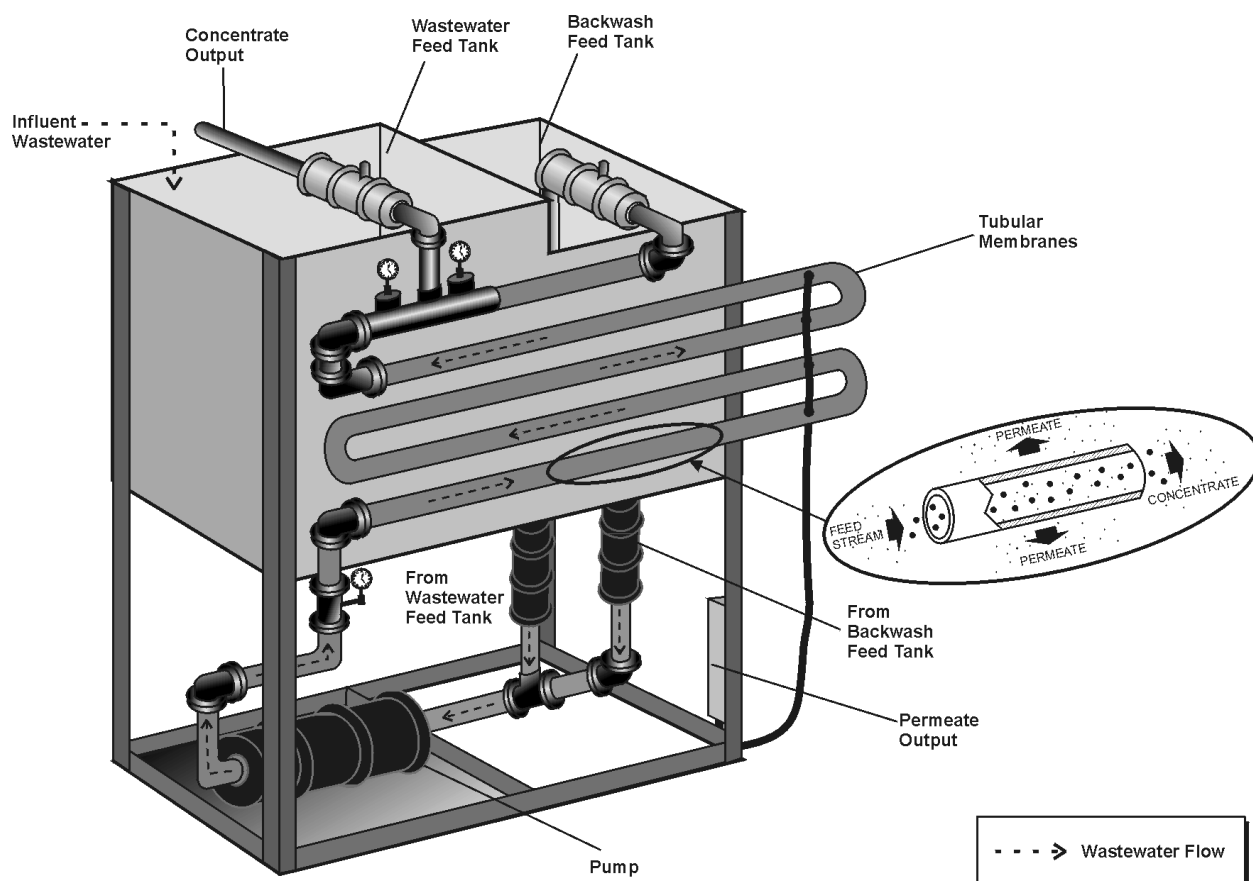
Figure 8-5. Membrane Filtration Unit

8.2.8.1   Ion Exchange (in-process)

Ion exchange is a commonly used technology within MP&M facilities. In addition to water recycling and chemical recovery applications, ion exchange is used to soften or deionize raw water for process solutions. Figure 8-6 shows a typical ion-exchange system.

Ion exchange is a reversible chemical reaction that exchanges ions in a feed stream for ions of like charge on the surface of an ion-exchange resin. Resins are broadly divided into cationic or anionic types. Typical cation resins exchange H^+ for other cations, while anion resins exchange OH^- for other anions (10).
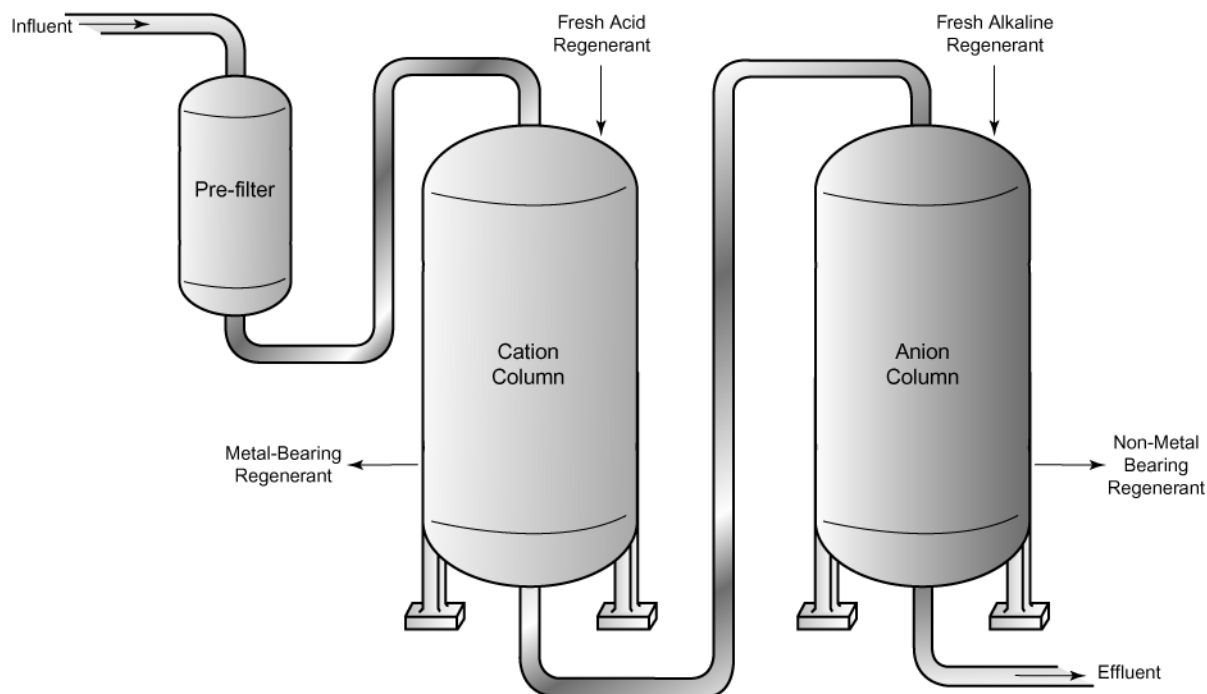
Figure 8-6. Ion Exchange

A feed stream passes through a column, which holds the resin. The feed stream is usually either dilute rinse water (in-process ion exchange) or treated wastewater (end-of-pipe ion exchange). Often, prior to ion-exchange treatment, the feed stream passes through a cartridge filter and a carbon filter to remove suspended solids and organic pollutants that foul the resin bed. The exchange process continues until the capacity of the resin is reached (i.e., an exchange has occurred at all the resin sites). A regenerant solution then passes through the column. For cation resins, the regenerant is an acid, and the H^+ ions replace the cations captured from the feed stream. For anion resins, the regenerant is a base, and OH^- ions replace the anions captured from the feed stream. The metals concentration is much higher in the regenerant than in the feed stream; therefore, the ion-exchange process not only separates the metals from the waste stream but also results in a more concentrated waste stream.

MP&M facilities use ion exchange for water recycling and metal recovery. For water recycling, cation and anion columns are placed in series. The feed stream is deionized and the product water is reused for rinsing. Often, the system can achieve closed-loop rinsing. The regenerant from the cation column contains metal ions, which are recoverable in elemental form via electrolytic recovery (see Section 8.2.6). The anion regenerant typically flows to wastewater treatment. Facilities use this type of ion exchange to recycle relatively dilute rinse streams. Generally, the TDS concentration of such streams must be below 500 mg/L to maintain an

efficient regeneration frequency. Reducing drag-out can enhance the efficiency of the recovery process. Effluent TDS concentrations of 2 mg/L or less are typical.

When facilities are seeking only metal recovery, they use a single or double cation column unit containing selective resin. These resins attract divalent cations while allowing monovalent cations to pass, a process usually called metal scavenging. This technology is efficient if the metal ions being scavenged are the primary source of ions in the stream. Ion exchange provides effective metals recovery even when the metal content of the stream is only a small fraction of the TDS present in the stream, making scavenging suitable over a wider range of TDS than water recycling. Scavenging also provides a highly concentrated regenerant, particularly suitable for electrolytic recovery (see Section 8.2.6). Water recycling using this ion exchange configuration is not possible because only some of the cations and none of the anions are removed. Standard units typically achieve effluent metal concentrations of under 0.5 mg/L.

Many process wastewaters are excellent candidates for ion exchange, including the rinse water from plating processes of chromium, copper, cadmium, gold, lead, nickel, tin, tin-lead, and zinc. Ion exchange resins usually are regenerated using inexpensive chemicals such as sulfuric acid and sodium hydroxide. Gold-bearing resins are difficult to regenerate and frequently require incineration to recover the gold content. Lead also is difficult to recover from ion exchange resins. Methane sulfonic acid and fluoboric acid (usually not suitable for electrolytic recovery) are effective regenerants for lead ion exchange but are very expensive. Cyanide rinse waters are amenable to ion exchange; cation resins can break the metal-cyanide complex and the cyanide is removed in the anion column. The metals in the cation regenerant can be recovered electrolytically and the cyanide present in the anion regenerant can be returned to the process or discharged to treatment.

Ion-exchange equipment ranges from small, manual, single-column units to multi-column, highly automated units. Two sets of columns are necessary for continuous treatment; one set receives the wastewater flow while the other set is being regenerated. Thus, two-column metal scavenging and four-column deionizing systems are common. Automatic systems direct the wastewater flow and initiate regeneration with little or no operator involvement.

The labor requirements for ion exchange depend on the automation level of the equipment. Manual systems can have significant labor costs associated with preparing, transporting, and disposing of regenerants. Automatic systems require far less labor. Resins need to be replaced periodically due to organic contamination, resin oxidation, and fouling from suspended solids. This process can be hastened by misuse, accidents, or poor engineering.

Equipment size is based on flow rate and concentration. Resin capacity varies but often ranges from 1 to 2 lbs/ft^3. Flow rates may range from 1 to 20 or more gpm. Columns typically are sized to handle wastewater flow for at least a period of time equal to that required for regeneration. Automatic systems are sized to provide continuous treatment. Regeneration volume typically ranges from 2 to 4 resin bed volumes of dilute acid or caustic. Concentrations of feed stream contaminants generally range from 10 to 20 g/L.

8.2.8.2   Reverse Osmosis

Reverse osmosis is a membrane separation technology used by MP&M facilities for chemical recovery and water recycling. The system pumps dilute rinse water to the surface of the reverse osmosis membrane at pressures of 400 to 1,000 pounds per square inch gauge (psig). The membrane separates the feed stream into a reject stream and a permeate. The reject stream, containing most of the dissolved solids in the feed stream, is retained by the membrane while the permeate passes through. Reverse osmosis membranes reject more than 99 percent of multivalent ions and 90 to 96 percent of monovalent ions, in addition to organic pollutants and nonionic dissolved solids. The permeate stream usually is of sufficient quality to be recycled as rinse water, despite the small percentage of monovalent ions (commonly potassium, sodium and chloride) that pass through the membrane. Reverse osmosis equipment is similar to the equipment shown in Figure 8-5.

A sufficiently concentrated reject stream can be returned directly to the process bath. Recycling the stream through the unit more than once or by increasing the feed pressure can increase the reject stream concentration. In multiple-stage units containing more than one membrane chamber, the reject stream from the first chamber is routed to the second, and so on. The combined reject streams from multistage units may, in some cases, have high enough concentrations to go directly back to the bath.

The capacity of reverse osmosis equipment generally is measured in flow volume, and is determined by the membrane surface area and operating pressure. Increasing the surface area of the membrane usually increases the membrane capacity. Operating at higher pressures increases the permeate flow volume per unit membrane area (also called the flux). Reject stream concentration increases with pressure and decreases as flow volume increases.

Facilities may need to prefilter and pretreat the feed stream to lengthen membrane life or reduce the frequency of fouling; filtration to remove suspended solids is usually necessary. Adjusting pH may prevent precipitation as the feed stream is concentrated, but it may make the concentrate unfit to return to the process bath.

Reverse osmosis is most applicable to electroplating rinse waters, including electroplating of Watts nickel, bright nickel, brass cyanide, copper cyanide, and zinc cyanide. This technology can treat TDS concentrations of up to 1,000 mg/L. Permeate TDS concentrations of 250 mg/L or less are typical, and the dissolved solids are mostly commonly monovalent ions, allowing the permeate stream to be reused in many rinsing operations.

The maximum achievable reject stream concentration for basic reverse osmosis equipment is approximately 20,000 mg/L TDS. Multipass and multistage units achieve concentrations of 30,000 mg/L TDS or higher. If the reject stream is acceptable to return directly to the process bath and the permeate is recycled as rinse water, a closed loop is created. However, returning the reject stream directly to the bath is uncommon because the concentration is often too low. When the reject stream concentration is not high enough to return it to the bath,

it can be concentrated with an evaporator, electrolytically recovered, or discharged to wastewater treatment. When evaporators are used, however, reverse osmosis loses its low-energy advantage over other in-process reuse and recovery technologies.

Reverse osmosis often has a higher capital cost than does ion exchange when both technologies include an electrolytic recovery unit. When used for water recycling, reverse osmosis and ion exchange both remove similar quantities of metals; however, reverse osmosis may allow for more water recycling.. During reverse osmosis, only the pumps use energy. In most cases, water is recycled; in some cases, a closed loop is possible. Compared to ion exchange, reverse osmosis can treat somewhat higher feed stream concentrations. The concentration of reverse osmosis reject streams are near or higher than that of ion-exchange regenerants. Both are less effective in handling oxidizing chemistries or feed streams high in organic compounds and total suspended solids. Ion-exchange effluent generally has a lower TDS concentration than does reverse osmosis permeate and can be recycled in most rinses.

For most applications, reverse osmosis membranes last for one to five years, although they are susceptible to fouling from organic pollutants, suspended solids, or misuse. Reverse osmosis units may be able to track the condition of the membrane by measuring the flux. If the membrane fouls or clogs, the flux rate drops, indicating that the membrane should be cleaned. Labor associated with operating reverse osmosis equipment is for periodic membrane cleaning. Membrane and pump replacement are the primary maintenance items.

8.3 Best Management Practices and Environmental Management Systems for Pollution Prevention

EPA encourages the wide spread use of Best Management Practices (BMPs), and Environmental Management Systems (EMS), to achieve improved environmental performance and compliance, pollution prevention through source reduction, and continual improvement (see EPA Position Statement on Environmental Management Systems, May 15, 2002, DCN 17848, Section 24.4). However, as described in the Section IV of the preamble to the final rule, EPA is not requiring the use of BMPs or EMSs for compliance with the MP&M effluent guidelines.

Best Management Practices (BMPs) are inherently pollution prevention practices. BMPs may include the universe of pollution prevention encompassing production modifications, operational changes, material substitution, materials and water conservation, and other such measures (17). BMPs include methods to prevent the discharge of toxic and hazardous pollutants. BMPs are most effective when organized into a comprehensive facility EMS.

MP&M facilities employ many types of pollution prevention measures including the following: training and supervision; production planning; process or equipment modification; raw material and product substitution or elimination; loss prevention and housekeeping; waste segregation and separation; and closed-loop recycling. These practices are discussed in further detail below (1).

- **Training and Supervision**
  Training and supervision ensure that employees are aware of, understand, and support the company's pollution prevention goals. Effective training programs translate these goals into practical information that enables employees to minimize waste generation by properly and efficiently using tools, supplies, equipment, and materials.

- **Production Planning**
  Production planning can minimize the number of process operation steps and eliminate unnecessary procedures (e.g., production planning can eliminate additional cleaning steps between process operations).

- **Process or Equipment Modification**
  Facilities can modify processes and equipment to minimize the amount of waste generated (e.g., changing rack configuration to reduce drag-out).

- **Raw Material and Product Substitution or Elimination**
  Where possible, facilities should replace toxic or hazardous raw materials or products with other materials that produce less waste and less toxic waste (e.g., replacing chromium-bearing solutions with non-chromium-bearing and less toxic solutions, or consolidating types of cleaning solutions and machining coolants).

- **Loss Prevention and Housekeeping**
  Loss prevention and housekeeping includes performing preventive maintenance and managing equipment and materials to minimize leaks, spills, evaporative losses, and other releases (e.g., inspecting the integrity of tanks on a regular basis; using chemical analyses instead of elapsed time or number of parts processed as the basis for disposal of a solution).

- **Waste Segregation and Separation**
  Facilities should avoid mixing different types of wastes or mixing hazardous wastes with nonhazardous wastes. Similarly, facilities should not mix recyclable materials with noncompatible materials or wastes. For example, facilities can segregate scrap metal by metal type, separate cyanide-bearing wastewater for preliminary treatment, and segregate coolants for recycling or treatment.

- **Closed-Loop Recycling**
  Facilities can recover and reuse some process streams. For example, some facilities can use ion exchange to recover metal from electroplating rinse water, reuse the rinse water, and reuse the regenerant solution as process solution make-up.

The following sections describe pollution prevention opportunities for a few MP&M facilities.

8.3.1 Pollution Prevention for Cleaning and Degreasing Operations

The majority of facilities in the Oily Wastes Subcategory perform cleaning and degreasing operations to remove residual oil and coolants from metal parts following machining and grinding operations. These facilities also perform cleaning and degreasing on equipment undergoing maintenance. Opportunities to reduce waste from these operations include process elimination, material substitution, in-process recycling, waste segregation, maintenance/ housekeeping, procedures/scheduling, and equipment layout/piping/automation. Examples of these opportunities are presented below (15).

Process Elimination

- Determine whether parts need to be cleaned;

- Use easy-to-clean or no-clean rust inhibitors and lubricants;

- Review the parts-handling process to determine why parts are getting dirty, and take action to prevent it from happening in the future; and

- Purchase clean input stock.

Material Substitution

- Clean by brushing and wiping where possible;
- Use aqueous-based cleaners;
- Use solvents with low vapor pressure and high flash point; and
- Use citrus or terpene cleaners.

In-Process Recycling

- Use countercurrent rinsing;

- Skim/filter and reuse aqueous cleaners;

- Reuse solvents by installing filtration or distillation units; and

- Install a bioremediation parts washer that uses enzymes to remove oil and grease.

Waste Segregation

- Segregate solvents to allow recycling;

- Keep solvents out of waste oil;

- Keep fuel, brake fluid and other fluids out of solvents to prevent the mixture from becoming hazardous; and

- Keep solvents out of aqueous cleaners.

Maintenance/Housekeeping

- Use secondary containment for solvent storage; and
- Implement a maintenance program to fix and prevent leaks.

Procedures/Scheduling

- Reduce dragout by increasing drain time; and
- When dripping parts, lift them such that it reduces dragout.

Equipment Layout/Piping/Automation

- Install sliding lids on solvent tanks;
- Increase the freeboard height to significantly reduce solvent evaporation;
- Install automatic parts lift on vapor degreasers;
- Use drain racks to reduce dragout; and
- Drain parts using a rotating rack.

8.3.2 Pollution Prevention for Machining Operations

Many machining operations use metal-working fluids to cool and lubricate parts and machining tools during cutting, drilling, milling, and other machining operations. These fluids become contaminated and begin to lose their working characteristics. If neglected, the fluids become unusable and require treatment and disposal. Through proper care, the life span of the fluids can be extended indefinitely. For most machining operations, prolonging metal-working fluid life reduces the cost of treatment and disposal, as well as the cost of fresh coolant.

Many MP&M facilities use some type of pollution prevention and water conservation practices for machining wastewaters. Some facilities have implemented numerous pollution prevention and water conservation methods and technologies that result in very low machining wastewater discharge rates and in some cases eliminate the discharge of machining fluids. Pollution prevention and water conservation practices are applicable to all machining

operations; however, process-related factors and site-specific conditions may restrict the utility of certain methods.

The Agency has identified two categories of pollution prevention and water conservation practices and technologies that can be used to reduce metal-working fluid discharge: those used to prevent metal-working fluid contamination and those used to extend the life of machining fluids, including recovering and recycling metal-working fluids. Within each of these categories are several specific practices and technologies. See Appendix D for more information on these pollution prevention practices.

8.3.3 Painting Operations

Paint is applied to a base material for protective and decorative reasons in various forms, including dry powder, solvent-diluted formulations, and water-borne formulations. There are various methods of application, the most common being immersion and spraying. Water is used in painting operations in paint booth water-wash systems (water curtains), in water-borne formulations, in electrophoretic painting solutions and rinses, and in clean-up operations. This discussion is directed at water use in spray painting booths; however, Appendix D also provides some information on rinsing following electrophoretic painting and water clean-up.

EPA has identified three categories of pollution prevention and water conservation practices that, if implemented, can reduce or eliminate wastewater discharges from painting operations: practices to reduce the quantity of paint entering the water system; recycling technologies for paint booth water; and conversion of water-wash booths to dry-filter booths. These are discussed in this subsection and summarized in Appendix D. It is possible, however, that facilities can reduce or eliminate wastewater discharges using different practices than those described here.

8.3.4 Pollution Prevention for Printed Wiring Board Manufacturing

Printed wiring board manufacturers use a large amount of water each day, mostly for rinsing and electroplating processes. The following BMP's developed specifically for printed wiring board manufacturing outline water-saving process changes and controls that can be inexpensively incorporated in the production process. A number of these pollution prevention processes are described in more detail in Section 8.1.

- Use dry film photoresist instead of wet applications.

- Examine the pre-plating rinse processes:

  - Based on monitoring data, eliminate unnecessary cycles and rinse only until desired cleanliness is reached.

  - Switch from continuous to on-demand rinsing, and from once-through to closed-loop use.

- Use counter-current rinsing.

- Use air or workpiece agitation to increase rinsing efficiency.

- Spray rinse with high-pressure, low flow nozzles. This can reduce rinse water use up to 60 percent.

- Link flow controls to conductivity meters that measure the total dissolved solids in the rinses.

- Examine the electroplating process. Extending bath life will reduce both water consumption and toxics in the effluent.

  - Reduce drag-in through efficient rinsing.

  - Use deionized or distilled water for makeup.

  - Reduce drag-out through the following methods:

    a) Minimize bath chemical concentrations.

    b) Use nonionic wetting agents to reduce surface tension in the process baths.

    c) Prior to rinsing, maximize water returned to the process bath through several measures – withdraw pieces from the baths slowly, install drainage boards between process baths and rinses to return drag-out back to the process bath, install rails above process baths to hang workpiece/racks for drainage and/or use air knives or spray rinses above process baths to rinse excess solution into the process bath.

  - Restore barrel holes.

  - Maintain bath solution quality through monitoring, replacement of reagents and stabilizers, and impurity removal.

- Install multiple baths after the process bath for using counter-current rinsing wherever possible.

8.4   Preliminary Treatment of Segregated Wastewater Streams

Preliminary treatment systems reduce pollutant loadings in segregated waste streams prior to combined end-of-pipe treatment. Wastewater containing pollutants such as

cyanide, hexavalent chromium, oil and grease, or chelated metals may not be treated effectively by chemical precipitation and gravity settling without preliminary treatment. Proper segregation and treatment of these streams is critical for the successful treatment of process wastewater. Highly concentrated metal-bearing wastewater also may require pretreatment to reduce metal concentrations before end-of-pipe treatment. This subsection describes the following wastewater streams that typically undergo preliminary treatment at MP&M facilities:

- Chromium-bearing wastewater;
- Concentrated metal-bearing wastewater;
- Cyanide-bearing wastewater;
- Chelated metal-bearing wastewater; and
- Oil-bearing wastewater.

Table 8-3 summarizes these preliminary treatment operations.

8.4.1 Chromium-Bearing Wastewater

MP&M facilities generate hexavalent-chromium-bearing wastewater from acid treatment, anodizing, conversion coating, and electroplating operations and rinses. Hexavalent chromium exists in an ionic form and does not form a metal hydroxide; therefore, hexavalent chromium cannot be treated by chemical precipitation and sedimentation (discussed in Section 8.5.1). The wastewater requires preliminary chemical treatment to reduce the hexavalent chromium to trivalent chromium, which can be removed by chemical precipitation and sedimentation. As shown in Table 8-3, EPA estimates there are over 1,800 MP&M facilities that perform hexavalent chromium reduction. The chemical reduction process is discussed below. Figure 8-7 presents a diagram of a continuous chromium reduction system.

Table 8-3

MP&M Preliminary and End-of-Pipe Treatment Technologies

Technology	Technology Description	Demonstration Status		
		Number of Facilities Visited Using the Technology [a]	Number of Survey Facilities Using the Technology [b]	Estimated Number of MP&M Facilities Using the Technology [c]
Chemical Emulsion Breaking Followed by Gravity Oil/Water Separation	Adds acids (typically sulfuric), polymer, and sometimes alum to oil-bearing wastewater to break oil/water emulsions for subsequent gravity separation. Separated oil is skimmed and hauled by a contractor. A facility may purchase the recycled oil for reuse.	13	56	958
Chemical Emulsion Breaking Followed by Dissolved Air Flotation	Adds acids (typically sulfuric), polymer, and sometimes alum to oil-bearing wastewater to break oil/water emulsions for subsequent gravity separation. Introduces gas bubbles into the wastewater, bringing oils and solids to the surface for subsequent removal.	85	25	244
Chemical Reduction of Hexavalent Chromium	Reduces hexavalent chromium to trivalent chromium using a reducing agent such as sulfur dioxide, sodium bisulfite, or sodium metabisulfite.	56	103	1,839
Cyanide Destruction by Alkaline Chlorination	Destroys cyanide by adding chlorine (usually sodium hypochlorite or chlorine gas) to high pH wastewater to first oxidize cyanide to cyanate, then cyanate to carbon dioxide and nitrogen gas.	14	53	1,136
Oil Skimming of Oily Wastewater Streams	Removes free floating oil by gravity separation and mechanical skimming. This technology does not remove emulsified oils.	45	89	2,087
Cyanide Oxidation by Ozone	Ozone oxidizes cyanide to ammonia, carbon dioxide and oxygen.	0	1	4
Chelation Breaking/ Precipitation to Remove Complexed Metals	Wastewater from electroless plating and some cleaning operations contains chelated metals that cannot be removed by chemical precipitation. Strong reducing agents such as dithiocarbamate are added to break the metal-organic chelate bond and precipitate the metal.	15	49	555
Ultrafiltration	Removes emulsified or free-floating oils. This technology also removes other solids. Uses a membrane of very small pore size.	19	23	351
Activated Carbon Adsorption	Removes dissolved organic pollutants by filtration through and adsorption on activated carbon. This technology requires preliminary treatment to remove suspended solids and oil and grease.	9	21	165
Aerobic Biological Treatment	Biochemically decomposes organic materials in the presence of oxygen using microorganisms.	1 (used to treat nonprocess wastewater)	4	130
Air Stripping	Removes dissolved volatile organic pollutants by contacting the organics in the wastewater with a continuous stream of air bubbles. Volatile organic pollutants are transferred from the wastewater to the air.	0	2	14

Table 8-3 (Continued)

Technology	Technology Description	Demonstration Status		
		Number of Facilities Visited Using the Technology [a]	Number of Survey Facilities Using the Technology [b]	Estimated Number of MP&M Facilities Using the Technology [c]
Neutralization	Neutralizes high or low pH wastewater to within an acceptable range using acidic or alkaline chemicals. Common acids include sulfuric and hydrochloric. Common alkaline chemicals include lime and sodium hydroxide.	63	233	3,713
Chemical Precipitation and Gravity Sedimentation	Removes metals by precipitating insoluble compounds such as hydroxides, sulfides, or carbonates. Precipitation as metal hydroxides using lime or sodium hydroxide is the most common. Precipitated and flocculated solids are removed by gravity sedimentation in a clarifier.	149	203	2,981
Chemical Precipitation and Microfiltration	Removes metals by precipitating insoluble compounds such as hydroxides, sulfides, or carbonates. Precipitation as metal hydroxides using lime or sodium hydroxide is the most common. Precipitated and flocculated solids are removed by microfiltration through a porous membrane.	6	5	36
Atmospheric Evaporation	Includes both natural solar evaporation and forced atmospheric evaporation by which the evaporation rate is accelerated by increased temperature, air flow, and surface area.	4	12	142
Ion Exchange (end-of-pipe)	Polishing technique after metals precipitation to scavenge low concentrations of residual metals (cations) using combined cation and anion exchange. Anions remain in solution and are discharged. Concentrated metal-containing regenerants are typically returned to the metals precipitation system.	17	39	251
Multimedia Filtration	Removes solids from wastewater using filter media of different grain size. Coarser media remove larger particles and finer media remove smaller particles. Media include garnet, sand, and anthracite coal. The filter is periodically backwashed to remove solids.	12	16	354
Sand Filtration	Removes solids from wastewater using a sand filter. The filter is periodically backwashed to remove solids.	46	41	830
Gravity Settling	Physically removes suspended particles by gravity. This technology does not include the addition of any chemicals.	7	46	1,679
Centrifugation of Sludge	Separates water from solids using centrifugal force. Centrifugation dewaters sludges, reducing the volume and creating a semisolid cake. Centrifugation of sludge can typically achieve a sludge of 20-35 percent solids.	7	9	127
Gravity Thickening of Sludge	Physically separates solids and water by gravity. Gravity thickening can typically thicken sludge to 5 percent solids.	83	85	1,161

Table 8-3 (Continued)

Technology	Technology Description	Demonstration Status		
		Number of Facilities Visited Using the Technology [a]	Number of Survey Facilities Using the Technology[b]	Estimated Number of MP&M Facilities Using the Technology[c]
Pressure Filtration of Sludge	Physically separates solids and water by pressure filtration. Most commonly performed in a plate-and-frame filter press where the sludge builds up between the filter plates and water is filtered through a cloth. Pressure filtration can produce a sludge cake with greater than 40 percent solids.	140	189	3,106
Sludge Drying	Dries sludge by heating, which causes the water in the sludge to evaporate.	28	48	835
Vacuum Filtration of Sludge	Physically separates solids and water by vacuum filtration. Most commonly performed in a cylindrical drum vacuum filter, where water is pulled by vacuum through the filter and dewatered sludge is retained and subsequently scraped from the filter surface. Vacuum filtration can produce a sludge cake with 20 - 30 percent solids.	11	9	193

Source: MP&M site visits, MP&M sampling episodes, MP&M surveys and technical literature. Statistics specific to wastewater-discharging facilities.

[a]Indicates the number of MP&M facilities visited by EPA using the listed technology. EPA visited a total of 221 facilities.

[b]Indicates the number of water-discharging survey facilities that reported using this technology. Based on 874 MP&M survey respondents for the 1996 detailed survey and the 1989 survey.

[c]Indicates the estimated number of MP&M facilities currently performing this technology based on the 1989 and 1996 detailed surveys. EPA's national estimate of the 1996 detailed survey and the 1989 survey includes approximately 44,000 water-discharging facilities. EPA estimated numbers in this column using statistical weighting factors for the MP&M survey respondents. See Section 3.0 for a discussion of the development of national estimates and statistical survey weights.
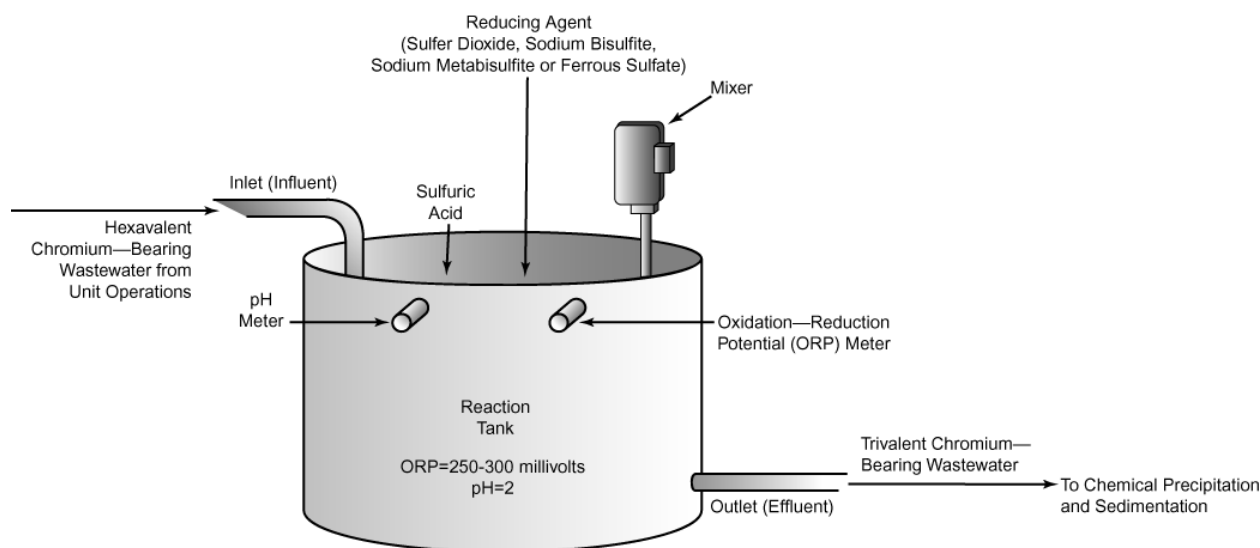
Figure 8-7. Chemical Reduction of Hexavalent Chrome

Reduction is a chemical reaction in which electrons are transferred from one chemical (the reducing agent) to the chemical being reduced. Sulfur dioxide, sodium bisulfite, sodium metabisulfite, peroxide, and ferrous sulfate form strong reducing agents in water. MP&M facilities use these agents to reduce hexavalent chromium to the trivalent form, which allows the metal to be removed from solution by subsequent chemical precipitation.

Sodium metabisulfite, sodium bisulfite, and sulfur dioxide are the most widely used reducing agents at MP&M facilities (14). Below is an equation showing the sulfur dioxide reaction (reduction using other reagents is similar chemically):

$$2H_2CrO_4 \ + \ 3SO_2 \ \rightarrow \ Cr_2(SO_4)_3 \ + \ 2H_2O \qquad\qquad \text{(8-2)}$$

An operating pH of between 2 and 3 is normal for chromium reduction. At pH levels above 5, the reduction rate is slow, and oxidizing agents such as dissolved oxygen and ferric iron interfere with the reduction process by consuming the reducing agent.

Typically, the chemicals are retained in a reaction tank for 45 minutes. The tank is equipped with pH and oxidation-reduction potential (ORP) controls. Sulfuric acid is added to maintain a pH of approximately 2, and a reducing agent is metered to the reaction tank to maintain the target ORP.

Chemical reduction of hexavalent chromium is a proven technology that is widely used at MP&M facilities. Operation at ambient conditions requires little energy, and the process

is well suited to automatic control. For high concentrations of chromium, treatment chemical costs may be significant.

Maintenance of chemical reduction systems consists of sludge removal, the frequency of which depends on the concentration of contaminants. There also may be small amounts of sludge generated due to minor shifts in the solubility of the contaminants (e.g., iron hydroxides). This sludge can be removed by the sludge-handling equipment associated with subsequent end-of-pipe chemical precipitation and sedimentation.

8.4.2   Concentrated Metal-Bearing Wastewater

Facilities use several methods to manage concentrated metal-bearing wastewater from spent process solutions. Facilities may:

- Meter the concentrated metal-bearing wastewater slowly to the end-of-pipe chemical precipitation system and commingle it with other facility wastewater;

- Treat the concentrated metal-bearing wastewater in a batch pretreatment system; or

- Send concentrated metal-bearing wastewater for off-site treatment.

Batch pretreatment allows better control of the treatment system (e.g., the treatment chemicals can be better tailored to the specific solution being treated), better treatment of difficult-to-treat materials (e.g., photo-resist-bearing wastewater), and potential recovery of metals from the sludge. With batch treatment, facilities typically discharge effluent from the batch treatment tank to the end-of-pipe treatment system for additional polishing.

Batch chemical precipitation of concentrated metal-bearing wastewater typically occurs in a single stirred tank, where a precipitating agent (e.g., sodium hydroxide, lime, sodium sulfide) is added to create an insoluble metal hydroxide or sulfide complex. Following precipitate formation, a polyelectrolyte is added to flocculate the metal hydroxide or metal sulfide particles into larger clumps that will settle to the bottom of the reaction tank following mixing. Clarified effluent from the batch tank is discharged to the end-of-pipe treatment system and the settled sludge, typically containing only one type of metal, is transferred off-site for metals recovery.

8.4.3   Cyanide-Bearing Wastewater

Plating and cleaning wastewater may contain significant amounts of cyanide, which should be removed through preliminary treatment. In addition to its toxicity, cyanide forms complexes with metals that prohibit subsequent removal in chemical precipitation systems.

Cyanide typically is treated using alkaline chlorination with sodium hypochlorite or chlorine gas or by ozone oxidation. These two processes are described below.

8.4.3.1   Alkaline Chlorination

Alkaline chlorination is in wide use in industrial wastewater treatment to destroy cyanide. Table 8-3 shows there are over 1,100 MP&M facilities using alkaline chlorination to remove cyanide. Chlorine is typically used as either chlorine gas or sodium hypochlorite (i.e., bleach). The alkaline chlorination process oxidizes cyanides to carbon dioxide and nitrogen by the following two-step chemical reaction (10):
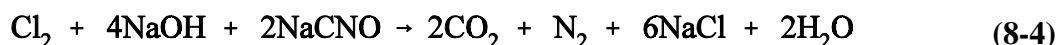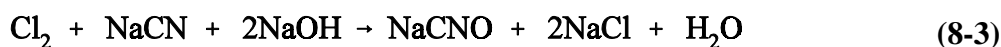
$$Cl_2 + NaCN + 2NaOH \rightarrow NaCNO + 2NaCl + H_2O \qquad \text{(8-3)}$$

$$Cl_2 + 4NaOH + 2NaCNO \rightarrow 2CO_2 + N_2 + 6NaCl + 2H_2O \qquad \text{(8-4)}$$

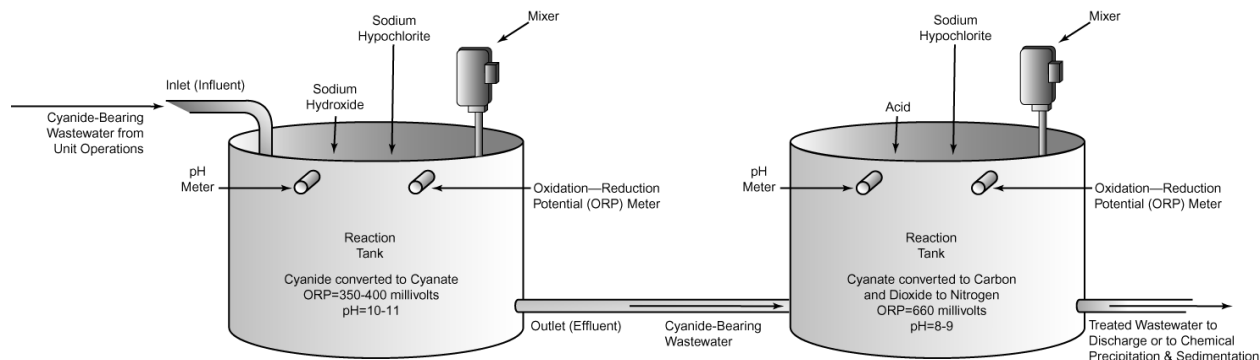Figure 8-8 presents a diagram of an alkaline chlorination system.

Figure 8-8. Cyanide Destruction Through Alkaline Chlorination

Treatment equipment often consists of an equalization tank followed by two continuous reaction tanks, although the batch reaction can occur in a single tank. Each tank has an electronic controller to monitor and maintain the required pH and ORP. To oxidize cyanides to cyanates, chlorine or sodium hypochlorite is metered to the first reaction tank as necessary to maintain the ORP at 350 to 400 millivolts, and aqueous sodium hydroxide is added to maintain a pH of approximately 11. This pH dictates that most of the cyanide exists in the CN⁻ form, rather than as the highly toxic hydrogen cyanide (HCN) form. In the second reaction tank, the ORP and the pH level typically are maintained at 600 millivolts and 8 to 9, respectively, to oxidize cyanate to carbon dioxide and nitrogen. Each reaction tank has a chemical mixer designed to provide approximately one turnover per minute.
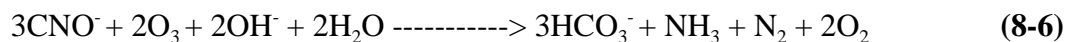
The batch process typically occurs in two tanks, one to collect water over a specified time period and one to treat an accumulated batch. If concentrated wastes are

frequently dumped, another tank may be required to equalize the flow to the treatment tank. When the holding tank is full, the liquid is transferred to the reaction tank for treatment.

Alkaline chlorination can take place at ambient temperature, can be automatically controlled at relatively low cost, and can achieve effluent concentrations of free cyanide that are below the detection limit. Disadvantages include the need for careful pH control, possible chemical interference in treating mixed wastes, and the potential hazard of storing and handling chlorine gas (if sodium hypochlorite is not used). If organic compounds are present, chlorinated organic compounds may be generated. Additionally, there are several safety concerns associated with handling chlorine gas and with the gas feed system. This technology is not effective in treating metallocyanide complexes, such as ferrocyanide.

8.4.3.2   Ozone Oxidation

A less common cyanide treatment method is ozone oxidation. Ozone, generated as a gas, is bubbled through a wastewater solution containing free cyanide. The ozone reacts with cyanide, converting it to cyanate. Additional ozone reacts with the cyanate to convert it to nitrogen gas, ammonia, and bicarbonate, as shown by the reactions below.

$$CN^- + O_3 \quad \text{-------}> CNO^- + O_2 \tag{8-5}$$

$$3CNO^- + 2O_3 + 2OH^- + 2H_2O \text{-----------}> 3HCO_3^- + NH_3 + N_2 + 2O_2 \tag{8-6}$$

The reaction rate is limited by mass transfer of ozone to the solution, the cyanide concentration, and temperature. Literature data show that oxidation can reduce amenable cyanide in electroplating wastewaters to below detection (5). Ozone is not effective in treating metallocyanide complexes, such as ferrocyanide, unless ultraviolet light is added to the reaction tank (6).

One advantage ozone has over chlorine is the type of residuals formed. Chlorine oxidation of organic compounds has the potential to form trihalomethanes. Ozone oxidizes organic compounds to form relatively less toxic, short-chain organic acids, ketones, and aldehydes. Equipment required for ozone oxidation of cyanides includes an ozone generator, gas diffusion system, a mixed reaction tank, and off-gas controls to prevent the release of unreacted ozone.

The major disadvantage of the ozone oxidation process is the capital and operating cost (12). Ozone must be manufactured on-site and delivered directly to the reaction tank. Ozone generation equipment is expensive, and facilities also must purchase closed reaction tanks and ozone off-gas treatment equipment.

8.4.4   Chelated-Metal-Bearing Wastewater

Certain process wastewaters evaluated for the final rule contain chelating agents that form metal complexes and interfere with conventional chemical precipitation treatment. This wastewater is often associated with electroless plating and requires specific treatment for the chelated metals. In general, there are three methods of treating these wastewaters:

- Reduction to elemental metal;
- Precipitation as an insoluble compound; and
- Physical separation.

8.4.4.1   Reduction to Elemental Metal

Reduction to elemental metal can be done using one of two methods. One method is electrolytic recovery (see Section 8.2.6), in which the dissolved metal is deposited on a cathode for reclamation or disposal. The electric current provides the electrons to reduce the metal ion to its elemental form. The reaction rate and achievable concentration for this technology depend on the volume of wastewater per unit surface area of cathode. This method typically does not lower metal concentrations to levels sufficient for wastewater discharge.

The second method uses a reducing agent to provide the electrons to reduce the metal. Possible reducing agents for treating chelated wastewater streams include:

- Dithiocarbamate (DTC);
- Sodium borohydride;
- Hydrazine; and
- Sodium hydrosulfite.

Upon reduction, the metal forms a particulate in solution, which a solids removal technique, such as gravity clarification, can remove. For effective use, these reducing agents sometimes require the use of other chemicals (e.g., lime or sodium hydroxide) for pH adjustment. Figure 8-9 presents a diagram showing this method of chemical reduction of chelated metals.
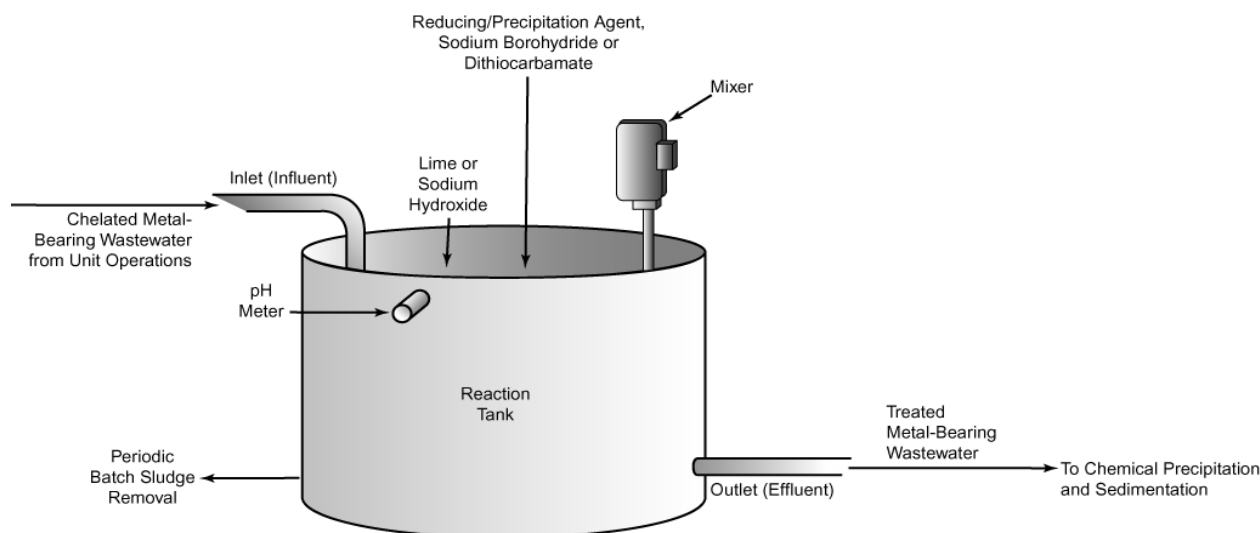
Figure 8-9. Chemical Reduction / Precipitation of Chelated Metals

8.4.4.2   Precipitation as an Insoluble Compound

Chelating agents hinder the formation of hydroxides, making hydroxide precipitation ineffective for treating chelated-metal-bearing wastewaters. Other precipitation methods that are less affected by chelating agents include sulfide precipitation, DTC precipitation, and carbonate precipitation. Section 8.5.1 discusses sulfide precipitation and carbonate precipitation.

DTC is added to solution in stoichiometric ratio to the metals present. Equation 8-7 shows the reduction of nickel using DTC:

$$Ni^{2+}_{(aq)} + DTC^{2-}_{(aq)} \rightarrow Ni^0_{(s)} \tag{8-7}$$

DTC is effective in treating wastewater containing chelated metals. Based on information provided in the MP&M Detailed Surveys, approximately 53 percent of MP&M facilities with chelated metals use DTC for treatment. DTC compounds are a class of pesticides and, if used incorrectly, may cause process upsets in the biological treatment system used at the POTW and can potentially be harmful to the environment (e.g., lead to fish kills if it passes through the POTW and reaches surface waters). Another disadvantage is that DTC precipitation generates large amounts of sludge.

Other treatment chemicals used by MP&M industries for treatment of chelated metals include:

- Borohydride;
- Sodium hydrosulfite;

- Sodium metabisulfite;
- Polysulfide polymer;
- Sodium hydroxide;
- Ferrous sulfate;
- Ferris chloride; and
- Formaldehyde.

EPA evaluated the treatment performance of polysulfide polymer (Sampling Episode 6462) and determined this compound effectively treated chelated copper and nickel to metal finishing effluent limits (40 CFR 433). Further concentration reductions may have been achievable if additional jar testing was conducted. Iron or calcium salts and pH adjustment may also provide acceptable methods for chelated metals treatment; however, no data are available for evaluation.

The Orange County Sanitation District (OCSD) compile a study of a NDMA and found that the highest concentrations of a probable human carcinogen, n-nitrosodimethylamine (NDMA), at a printed circuit board manufacturer were observed at effluent from batch treatment (18). "Overdosing" of DTC in batch treatment systems may be common and may lead to the formation of NDMA. During its evaluation OCSD encouraged facilities and treatment chemical vendors to develop non-NDMA forming treatments. EPA compiled information on DTC alternative treatments for the record (see "DTC Alternatives for Treatment of Chelated Metals," Section 24.6.1 of the rulemaking record, DCN 17962).

8.4.4.3 Physical Separation

Ion exchange and reverse osmosis can separate metals from solution. These technologies are not affected by chelating agents in the wastewater, making them effective in treating wastewater from electroless plating. Sections 8.2.8.1 and 8.2.8.2, respectively, discuss these technologies.

8.4.5 Oil-Bearing Wastewater

Some MP&M wastewater (e.g., alkaline cleaning wastewater and water-based metal-working fluids) contains significant amounts of oil and grease. This wastewater sometimes requires preliminary treatment to remove oil and grease and organic pollutants. Oil/water separation includes breaking oil/water emulsions (oil dispersed in water, stabilized by electrical charges and emulsifying agents) as well as gravity separation of oil. When only free oil (i.e., nonemulsified oil) is present, oil skimming is enough for effective treatment. Techniques available to remove oil include chemical emulsion breaking followed by oil/water separation or dissolved air flotation (DAF), oil skimming, and ultrafiltration. These technologies are described in more detail below.

Oil/water separation not only removes oil but also removes organic compounds that are more soluble in oil than in water. Subsequent clarification removes organic solids

directly and may also remove dissolved organic compounds by adsorption on inorganic solids. In MP&M operations, sources of these organic compounds mainly are process coolants and lubricants, additives to formulations of cleaners, paint formulations, or leaching from plastic lines and other materials.

8.4.5.1   Chemical Emulsion Breaking

Chemical emulsion breaking is used to break stable oil/water emulsions. A stable emulsion will not separate or break down without chemical and or physical treatment. Chemical emulsion breaking is applicable to wastewater containing emulsified coolants and lubricants such as machining and grinding coolants and impact and pressure deformation lubricants. This technology also is applicable to cleaning solutions that contain emulsified oils. Figure 8-10 shows a diagram of a type of continuous chemical emulsion breaking system.
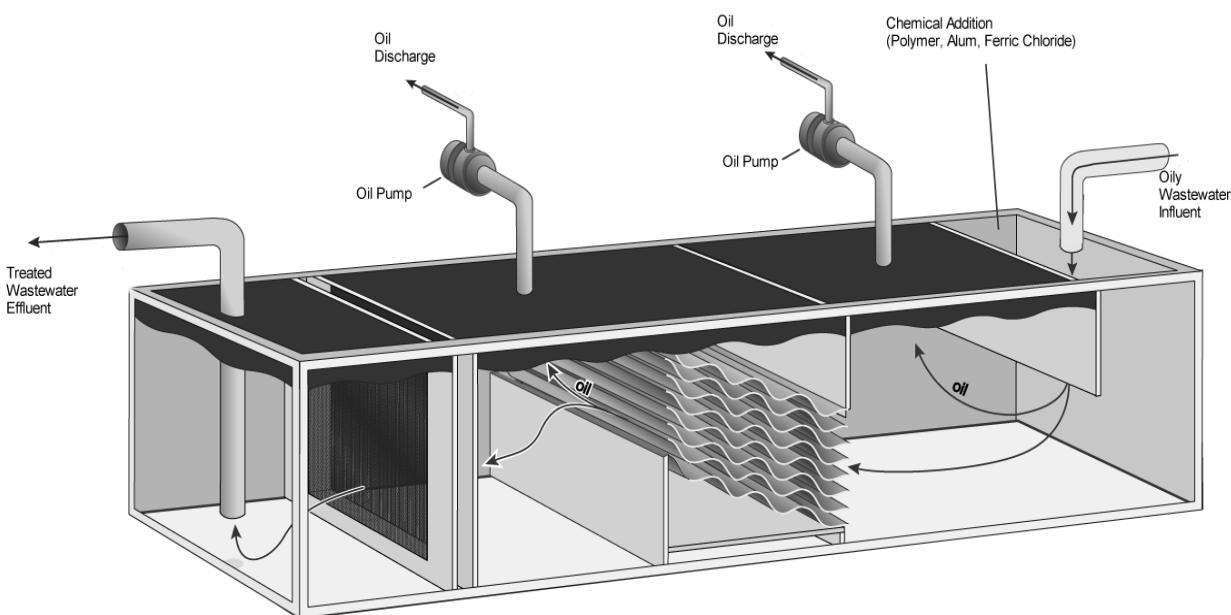

Figure 8-10. Continuous Chemical Emulsion Breaking Unit with Coalescing Plates

Treatment of spent oil/water emulsions involves adding chemicals to break the emulsion followed by oil/water separation. The major equipment required for chemical emulsion breaking includes reaction chambers with agitators, chemical storage tanks, chemical feed systems, pumps, and piping. Factors to be considered for breaking emulsions are type of chemicals, dosage and sequence of addition, pH, mixing, heating requirements, and retention time.

Chemicals (e.g., polymers, alum, ferric chloride, and organic emulsion breakers) break emulsions and allow coagulation (13) by neutralizing repulsive charges between particles, precipitating or salting out emulsifying agents, or weakening the interfacial film between the oil

and water so it is readily broken. Reactive cations (e.g., H^+, Al^{+3}, Fe^{+3}) and cationic polymers are particularly effective in breaking dilute oil/water emulsions. Once the charges are neutralized or the interfacial film broken, the small oil droplets and suspended solids either adsorb on the surface of the floc that is formed, or break out and float to the top. Different types of emulsion-breaking chemicals are used for different types of oils. If more than one chemical is required, the sequence of adding the chemicals can affect both breaking efficiency and chemical dosages.

Another important consideration in emulsion breaking is pH, especially if cationic inorganic chemicals, such as alum, serve as coagulants. For example, a pH of between 2 and 4 keeps the aluminum ion in its most positive state where it most effectively neutralizes charges. After some of the oil is broken free and skimmed, raising the pH into the 6-to-8 range with lime or caustic causes the aluminum to hydrolyze and precipitate as aluminum hydroxide. This floc entraps or adsorbs destabilized oil droplets, which can then be separated from the water. Cationic polymers can break emulsions over a wider pH range and thus avoid acid corrosion and the additional sludge generated from neutralization; however, this process usually requires adding an inorganic flocculent to supplement the adsorptive properties of the polymer emulsion breaker.

Mixing is important in effectively breaking oil/water emulsions because it provides proper chemical feed and dispersion. Mixing also causes droplets to collide and break the emulsion and promotes subsequent agglomeration into larger droplets. Heating also improves chemical emulsion breaking by lowering the viscosity and increasing the apparent specific gravity differential between oil and water. In addition, heating increases the frequency of droplet collisions, which helps to rupture the interfacial film.

Once an emulsion is broken, the oil floats to the surface of the water because of the difference in specific gravity between oil and water. Solids usually form a layer between the oil and water because some solids become suspended in the oil. The longer the retention time, the more complete the separation between the oil, solids, and water. Oils and solids typically are skimmed from the surface of the water after chemical emulsion breaking. Often, other techniques such as air flotation or rotational separation (e.g., centrifugation) enhance separation after chemical emulsion breaking.

The advantages of chemical emulsion breaking are the high removal efficiency potential and the possibility of reclaiming the oily waste. Disadvantages include corrosion problems associated with acid-alum systems, operator training requirements for batch treatment, chemical sludges produced, and poor efficiency for low oil concentrations.

Chemical emulsion breaking is a very reliable process. The main control parameters are pH and temperature. Some MP&M facilities may achieve effective emulsion breaking by lowering the pH with acid, by heating the wastewater, or both. Maintenance is required on pumps, mixers, instrumentation and valves, as is periodic cleaning of the treatment tank to remove any accumulated solids. Energy use typically is limited to mixers and pumps, but

also can include heating. Solid wastes generated by chemical emulsion breaking include surface oil and oily sludge, which are usually contract hauled for disposal by a licensed contractor. If the recovered oil contains a low enough percentage of water, it may be burned for its fuel value or processed and reused.

8.4.5.2   **Oil Skimming**

Oil skimming is a physical separation technology that removes free or floating oil from wastewater using the difference in specific gravity between oil and water. Common separation devices include belts, rotating drums, disks, and weir oil skimmers and coalescers. These devices are not suited to remove emulsified oil, which requires chemical treatment, ultrafiltration, or other treatment. Figures 8-11a and 8-11b show diagrams of disk and belt oil skimming units, respectively, that are applicable for small systems or on process tanks. The oil removal system shown in Figure 8-10 is a coalescing separator used for large systems.
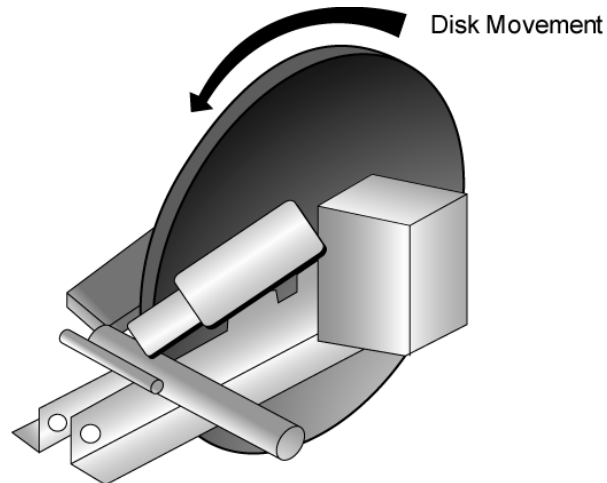

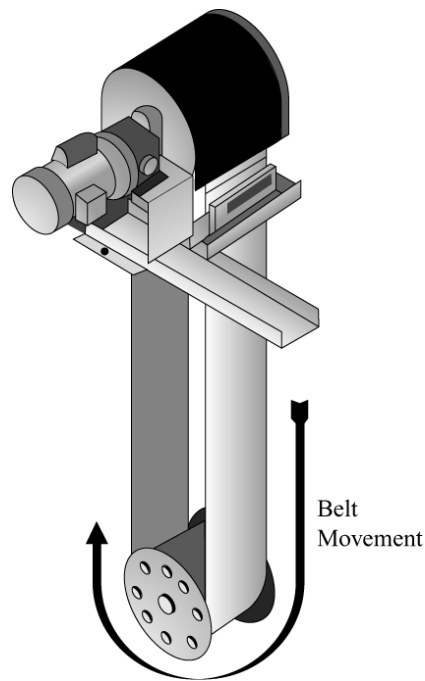**Figure 8-11a. Disk Oil Skimming Unit**

Figure 8-11b.
Belt Oil Skimming Unit

To separate oil from process solutions, oil skimming devices typically mount onto the side of a tank and operate on a continuous basis. The disk skimmer is a vertically rotating disk that is partially submerged in the solution (see Figure 8-11a). The disk continuously revolves between spring-loaded wiper blades that are located above the liquid surface. The disk's adhesive characteristics cause the floating oil to remain on the disk. As the disk's surface passes under the wiper blades, the blades scrape off the oil, which is diverted to a run-off spout for collection. Belt and drum skimmers operate in a similar manner, with either a continuous belt or drum rotating partially submerged in a tank. As the surface of the belt or drum emerges from the liquid, the oil that adheres to the surface is scraped off (drum) or squeezed off (belt) and diverted to a collection vessel. The oil typically is hauled off-site for disposal.

Gravity separators use overflow and underflow weirs to skim a floating oil layer from the surface of the wastewater. The oil layer flows over the weir into a trough for disposal or reuse while most of the water flows underneath the weir. A diffusion device, such as a vertical slot weir, helps create a uniform flow through the system and increase oil removal efficiency.

An oil skimmer's removal efficiency depends on the composition of the waste stream and the retention time of the water in the tank. Larger, more buoyant particles require less retention time than do smaller particles. The retention time necessary for phase separation and subsequent skimming varies from 1 to 15 minutes, depending on the wastewater characteristics. Gravity-type separators tend to be more effective for wastewater streams with consistently large

amounts of surface oil. Drum and belt type skimmers are more applicable to waste streams containing smaller amounts of floating oil. A gravity separator in conjunction with a drum-type skimmer effectively removes floating contaminants from nonemulsified oily waste streams.

Coalescers remove oil droplets too finely dispersed for conventional gravity separation-skimming technology. Coalescing also reduces the residence times (and therefore separator sizes) required to separate oil from some wastes. The basic principle of coalescence involves the attraction of oil droplets to the coalescing medium (typically plates). The oil droplets accumulate on the medium and then rise to the surface of the solution as they combine to form larger particles. The most important requirements for coalescing media are attraction for oil and large surface area. Coalescing media include polypropylene, ceramic, and glass.

Coalescing stages may be integrated with a wide variety of gravity oil separators, and some systems may incorporate several coalescing stages. A preliminary oil skimming step avoids overloading the coalescer.

8.4.5.3 Flotation of Oils or Solids

Air flotation combined with chemical emulsion breaking is an effective way to treat oily wastewater containing low concentrations of metals. Flotation separates oil and grease from the wastewater, and entrainment or adsorption will remove small amounts of metal. In DAF, air is injected into a fluid under pressure. The amount of air that can dissolve in a fluid increases with increasing pressure. When the pressure is released, the air comes out of solution as bubbles, which attach to oil and grease molecules and "float" the oil and grease to the surface. Induced-air flotation uses the same separation principles as DAF systems but the gas is self-induced by a rotor-disperser mechanism.

Figure 8-12 shows a diagram of a DAF unit. A DAF system consists of a pressurizing pump, air injection equipment, pressurizing tank, a pressure release valve, and a flotation tank. DAF systems operate in two modes: full-flow pressurization and recycle pressurization. In full-flow pressurization, all influent wastewater is pressurized and injected with air. The wastewater then enters the flotation unit where the pressure is relieved and bubbles form, causing the oil and grease to rise to the surface with the air bubbles. In recycle pressurization, part of the clarified effluent is recycled back to the influent of the DAF unit, then pressurized and supersaturated with air. The recycled effluent then flows through a pressure release valve into the flotation unit. Pressurizing only the recycle reduces the amount of energy required to pressurize the entire influent. DAF is the most common method of air flotation.
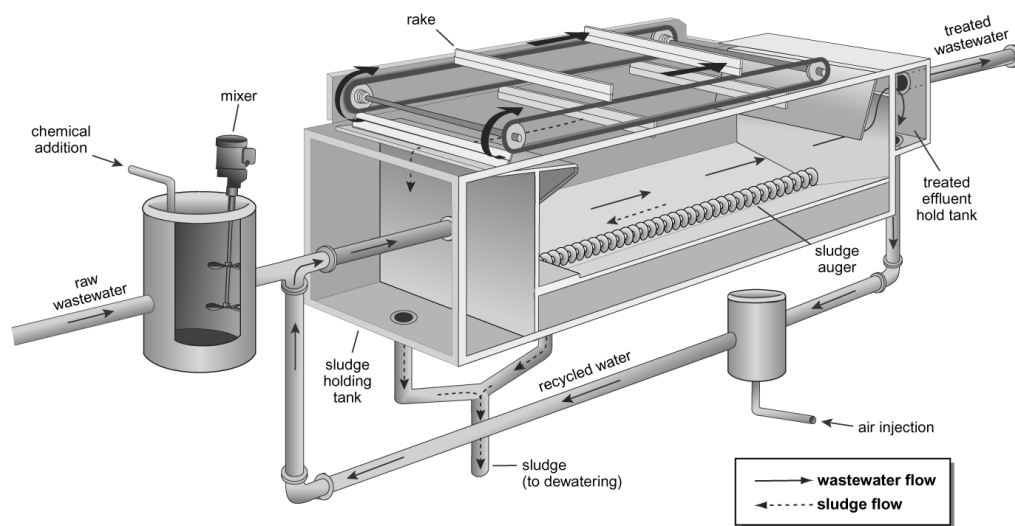
Figure 8-12. Dissolved Air Flotation Unit

8.4.5.4   Ultrafiltration

Ultrafiltration is a membrane-based process used to separate solution components based on molecular size and shape. Under pressure, solvent and small solute species pass through the membrane and are collected as permeate while the membrane retains larger compounds, which are recovered as concentrate. Figure 8-5 shows a typical membrane filtration unit.

Ultrafiltration typically removes materials ranging from 0.002 to 0.2 microns or molecular-weights from 500 to 300,000. It can be used to treat oily wastewater. Filtering the ultrafiltration influent removes large particles and free oil to prevent membrane damage and fouling. Most ultrafiltration membranes consist of homogeneous polymer or copolymer material. The transmembrane pressure required for ultrafiltration depends on membrane pore size, and typically ranges between 15 to 200 psi.

Ultrafiltration typically produces a concentrated oil phase that is two to five percent of the influent volume. Oily concentrates typically are hauled off-site or incinerated, and the permeate (water phase) can be either treated further to remove water-soluble metals and organic compounds or discharged, depending on local and state requirements.

An ultrafiltration system includes: pumps and feed vessels, piping or tubing, monitoring and control units for temperature, pressure, and flow rate; process and cleaning tanks; and membranes. Membranes are designed specifically to handle various waste stream

parameters, including temperature, pH, and chemical compatibility. There are different types of membranes, including hollow fiber, tubular, flat plate, and spiral wound. The type selected depends on the application. For example, tubular membranes commonly separate suspended solids, whereas spiral wound membranes separate oil from water. Ultrafiltration systems designed to remove oil typically are more expensive than are DAF systems. Membranes must be cleaned periodically to ensure effective treatment.

8.5   End-of-Pipe Wastewater Treatment and Sludge-Handling Technologies

This subsection describes end-of-pipe technologies that MP&M facilities use for wastewater treatment and sludge handling. Table 8-3 describes each technology and lists the number of MP&M facilities that use the technology. Section 8.5.1 discusses metal removal by chemical precipitation, Section 8.5.2 discusses oil removal technologies, Section 8.5.3 discusses wastewater polishing technologies, and Section 8.5.4 discusses sludge-handling technologies.

8.5.1   Chemical Precipitation for Metals Removal

The most common end-of-pipe treatment technology used at MP&M facilities to remove dissolved metals is chemical precipitation and flocculation followed by gravity clarification. The data in Table 8-3 show there are nearly 3,000 MP&M facilities that use chemical precipitation and gravity settling to treat their metals-bearing wastewater. Some MP&M facilities use microfiltration, filter press operations, centrifuge operations, DAF, and American Petroleum Institute (API) separation in place of clarification, but this subsection discusses only clarification and microfiltration. The types of equipment used for chemical precipitation vary widely. Small batch operations can take place in a single tank that typically has a conical bottom to permit removal of settled solids. Continuous processes usually occur in a series of tanks, including an equalization tank, a rapid-mix tank for dispersing the precipitating chemicals, and a slow-mix tank for adding coagulants and flocculants and for floc formation.

For continuous-flow systems, the first tank in the treatment train typically is the equalization tank. The flow equalization tank prevents upsets in processing operations from exceeding the hydraulic design capacity of the treatment system, improves chemical feed control, and allows wastewater neutralization.

Commingled wastewater from the equalization tank enters the rapid mix tank, along with various types of precipitation chemicals added to convert the soluble metals into insoluble compounds. Following precipitation, the wastewater flows into a flocculation tank where polyelectrolytes (polymers) are added, causing the precipitated solids to coagulate into larger particles that gravity settling or other separation techniques can remove.

Chemical precipitation is a highly reliable technology when properly monitored and controlled. The effectiveness of this technology depends on the types of equipment used and numerous operating factors, such as the characteristics of the raw wastewater, types of treatment reagents used, and operating pH. In some cases, subtle changes in operating factors (e.g., varying

the pH, altering chemical dosage, or extending the process reaction time) may sufficiently improve the system's efficiency. In other cases, modifications to the treatment system are necessary. For example, some raw wastewater contains chemicals that may interfere with metals precipitation, and may require additional, specialized treatment reagents such as ferrous sulfate, sodium hydrosulfate, aluminum sulfate, or calcium chloride. These chemicals may be added prior to or during the precipitation process.

Chemical precipitation systems require routine maintenance for proper operation. This includes: calibrating instrumentation and cleaning probes; maintaining chemical pumps and mixers (inspection, cleaning, lubrication, replacing seals and packing, replacing check valves, cleaning strainers); and monitoring tanks and sumps (inspection, cleaning, corrosion prevention).

There are several basic methods of performing chemical precipitation and flocculation and many variations of each method. The four most common methods are described below. Figure 8-13 shows a typical continuous chemical precipitation system.
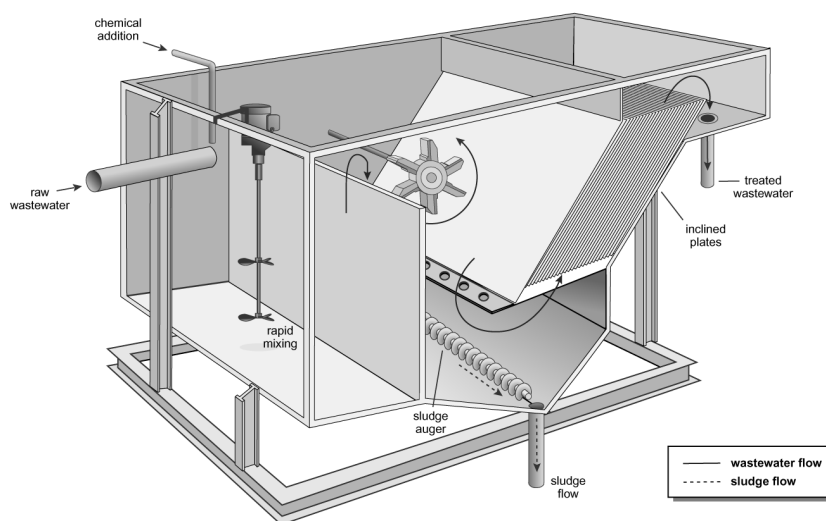

**Figure 8-13. Continuous Chemical Precipitation System with
Lamella Clarifier**

Removing precipitated metals typically involves adding flocculating agents or polymers to destabilize the hydrodynamic forces that hold the particles in suspension. For a continuous treatment system, polymer is either added in-line between the reaction tank and the flocculation tank, or in a small rapid mix tank between the reaction tank and flocculation tank. In the flocculation tank, the mixer is slowed to promote agglomeration of the particles until their density is greater than water and they settle from solution in the clarifier.

Hydroxide Precipitation

Hydroxide precipitation is the most common method of removing metals from MP&M wastewater. This process typically consists of several stages. In an initial tank, which is mechanically agitated, alkaline treatment reagents such as lime (calcium hydroxide or hydrated lime), sodium hydroxide, or magnesium hydroxide are added to the wastewater to precipitate metal ions as metal hydroxides. The reaction for precipitation of a divalent metal using sodium hydroxide is shown in the following equation:

$$M^{2+} + 2NaOH \rightarrow M(OH)_2 + 2Na^+ \tag{8-8}$$

The precipitation process usually operates at a pH of between 8.5 and 11, depending on the types of metals in the wastewater. The pH set point for each hydroxide precipitation system is determined by jar testing. Jar testing results determine the optimum pH, flocculent type and dosage to maximize the removal of target metals. Figure 8-14 shows the effect of pH on hydroxide precipitation. Figure 8-14 was developed based on empirical studies using single metal solutions in reagent-free water. However, metal solubilities in complex wastewater may differ from those shown in the figure, and therefore facilities must test their actual wastewater to define the minimum solubility for all metals.

Iron Coprecipitation

Iron coprecipitation is one method that has proven effective at reducing the concentration of metals such as arsenic, beryllium, cadmium, copper, lead, nickel and zinc to less than could be achieved with hydroxide precipitation alone (7). Iron coprecipitation involves adding an iron source such as ferric sulfate or ferric chloride to the pH adjustment tank in the chemical precipitation treatment system. Iron is then precipitated as iron oxyhydroxide (7). During this process, other metal hydroxides (e.g., nickel hydroxide, copper hydroxide) may be incorporated as an impurity within the iron oxyhydroxide matrix or physically entrapped within its pore spaces. Metal hydroxides may also be adsorbed to the surface of the iron oxyhydroxide precipitate. Factors affecting the iron coprecipitation process include iron dose and iron oxidation state, pH, the target metals oxidation state, the initial concentration of the target metal, and competition for adsorbent sites from other species. Facilities should conduct jar testing using their actual wastewater to optimize the operating conditions for this process.

Sulfide Precipitation

The sulfide precipitation process uses equipment similar to that used for hydroxide precipitation. The major difference between the two processes is the treatment reagents used. Sulfide precipitation uses either soluble sulfides (e.g., hydrogen sulfide or sodium sulfide) or insoluble sulfides (e.g., ferrous sulfide) in place of alkali reagents used in hydroxide precipitation. The sulfide reagents precipitate dissolved metals as metal sulfides, which often have lower solubility limits than metal hydroxides. Therefore, the sulfide precipitation process

can (for many metals) achieve lower levels of residual dissolved metal in the effluent than hydroxide precipitation treatment (see Figure 8-14). The sulfide precipitation reaction is shown in the following equation:

$$M^{2+} + FeS \rightarrow MS + Fe^{2+} \tag{8-9}$$

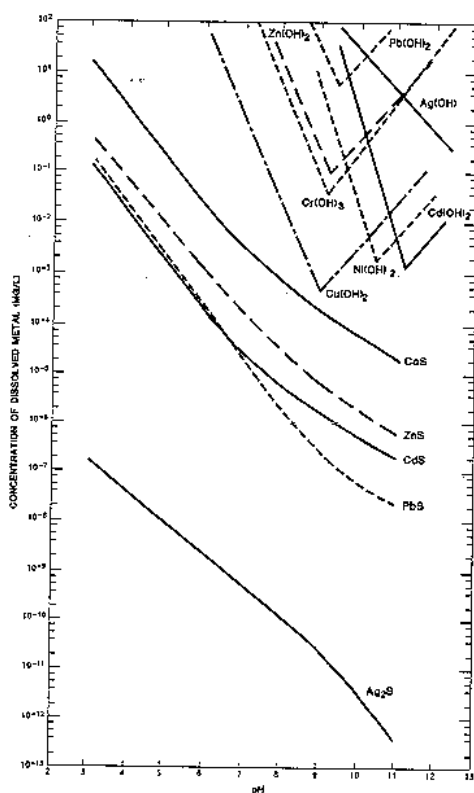**Figure 8-14. Effect of pH on Hydroxide and Sulfide Precipitation (10)**

Unlike hydroxides, sulfide can precipitate most chelated metals and can remove hexavalent chromium without first reducing the chromium to its trivalent state.

The major disadvantages of sulfide precipitation as compared to hydroxide precipitation are higher capital and operating costs. Additional disadvantages of sulfide

precipitation are the potential for toxic hydrogen sulfide gas generation and excessive sulfide releases in the effluent, and the generation of sulfide odors.

Carbonate Precipitation

Carbonate precipitation typically uses sodium carbonate (soda ash), sodium bicarbonate, or calcium carbonate to form insoluble metal carbonates. The reaction is shown in the following equation:

$$M^{2+} + Na_2CO_3 \rightarrow MCO_3 + 2Na^+ \qquad \text{(8-10)}$$
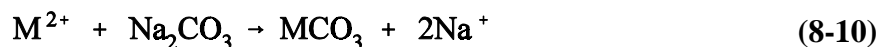
Carbonate precipitation is similar in operation to hydroxide precipitation, and its purpose is to remove metals such as cadmium or lead. For these metals, carbonate precipitation operates at a lower pH to achieve effluent concentrations similar to those achieved by hydroxide precipitation. Facilities sometimes operate carbonate precipitation in conjunction with hydroxide precipitation, which may improve the overall performance of certain systems.

Carbonate precipitation is less common than hydroxide precipitation due to the higher cost of treatment reagents and certain operational problems, such as the release of carbon dioxide, which can result in foaming and floating sludge. Also, because many metal carbonates are more soluble than are sulfides or hydroxides, this process does not effectively precipitate all target metals.

Chemical Precipitation Performance Factors

Ionic strength of the wastewater is another factor that can negatively affect the performance of the chemical precipitation system (8). As MP&M facilities lower water usage by implementing technologies such as flow restrictors, countercurrent cascade rinsing, and timed rinses, the ionic strength of the wastewater reaching the treatment system will increase. In process chemistry, a precipitate always forms or dissolves in the presence of indifferent electrolytes. Although ions from such species do not participate directly in the solubility equilibrium reaction, they do affect the solubility behavior of the precipitate. The following chemical equilibrium equations show the impact of ionic strength on the precipitation process:

$$CA_{(s)} \rightarrow C_{(aq)} + A_{(aq)} \qquad \text{(8-11)}$$

The equilibrium constant expression for this reaction is given by

$$(K_a)_{eq} = (C)(A) \qquad \text{(8-12)}$$

or

$$(K_a)_{eq} = g_m[C] \, g_m[A] \qquad \text{(8-13)}$$

This equation can be rewritten as

$$(K_e)_{eq} = (K_a)_{eq} / (g_m)^2 \qquad\qquad \textbf{(8-14)}$$

The greater the concentration of indifferent electrolytes, the greater the ionic strength of the solution and the smaller the value of the activity coefficient. In process chemistry, the value of g is normally less than 1.0. Therefore, the smaller the value of g, the larger the value of $(K_e)_{eq}$, indicating the solubility of the solid phase (metal hydroxide precipitate) will increase. This means that the solubility of a precipitate will increase if the concentration of indifferent electrolytes in solution increases (8). MP&M facilities that reduce process water usage should be aware of these equilibria changes that will occur within their treatment system. Facilities should conduct additional jar testing to determine if they can mitigate the negative impacts with new treatment chemistry or add process water to improve treatment efficiency.

One issue raised during the MP&M public comment period was that treatment system performance is fixed (i.e., percent removal) and therefore the effluent concentration is a direct function of influent concentration. The MP&M sampling episode data, however, indicate the effluent concentration is a function of the minimum solubility of the metal, regardless of the influent concentration. As explained in the June 2002 NODA (67 FR 38779), EPA reviewed graphical displays of the paired influent and effluent values and other data analyses. Because the results were inconclusive and sometimes inconsistent, EPA was unable to reach a conclusion about the effect of influent concentrations on the effluent concentrations. If a facility finds that influent concentrations appear to affect its effluent concentrations, it may be useful to perform jar testing on a representative sample of wastewater to optimize the treatment conditions for both high and low influent concentrations.

After precipitation, the metal hydroxide particles are very fine and resistant to settling. To increase their particle size and improve their settling characteristics, coagulating and flocculating agents are added, usually in a second tank, and slowly mixed. Coagulating and flocculating agents include inorganic chemicals such as alum and ferric sulfate, and a highly diverse range of organic polyelectrolytes with varying characteristics suitable for different wastewaters. The type and dosage of flocculent and coagulant are based on the results of jar testing done using the actual facility wastewater.

Flocculated particles with densities greater than water settle in a separate clarification tank (e.g., a lamella clarifier), under quiescent conditions. Operators remove the solids from the bottom of the settling tank or clarifier, then transfer them to a thickener or other dewatering process (see Section 8.5.4). Clarifier effluent either undergoes further processing in a polishing unit such as a multimedia filter or discharges.

8.5.1.1 Gravity Clarification for Solids Removal

Gravity sedimentation to remove precipitated metal hydroxides is the most common method of clarification (solids removal) used by MP&M facilities. Typically, two types of sedimentation devices are used: inclined-plate clarifiers (e.g., lamella clarifiers) and circular center-feed rim flow clarifiers.

Lamella clarifiers contain inclined plates oriented at angles varying between 45 and 60 degrees from horizontal. As the water rises through the clarifier, the solids settle on the plates. Clarified effluent continues to the top of the clarifier, passes over a weir, and collects in a holding tank. The solids collect on the inclined plates and slide downward and into the bottom of the clarifier. When sufficient solids collect in the bottom of the clarifier, they are scraped into a sludge hopper and then discharged, usually to a thickener. Figure 8-13 presents a lamella clarifier.

Overflow rates for lamella clarifiers (i.e., between 1,000 and 1,500 gpd/ft^2 for metal hydroxide sludges) are two to four times higher than the overflow rates for clarifiers not equipped with inclined plates. Clarifier inlets must be designed to distribute flow uniformly through the tank and plate settlers. In addition, because solids can build up on plate surfaces and adversely affect flow distribution, the clarifier should be cleaned periodically.

Lamella clarifiers are more common at MP&M facilities than other types of clarifiers because of the smaller area required. They typically require only 65 to 80 percent of the area required for clarifiers without inclined plates. Their design promotes laminar flow through the clarifier, even when the water throughput is relatively high.

In a center-feed rim flow clarifier, wastewater flows into the bottom of a center feed well and then up into a circular tank. Heavy particles settle to the bottom of the tank where they are raked to a discharge pipe and removed. Materials with a density less than the density of water float to the top of the water and are skimmed from the water surface and discharged to a scum pit through a scum trough. Scum is removed from the scum pit periodically and then disposed of. Clarified effluent flows over the top of the clarifier and is collected in an effluent channel and discharged. Figure 8-15 shows a center-feed rim flow clarifier.
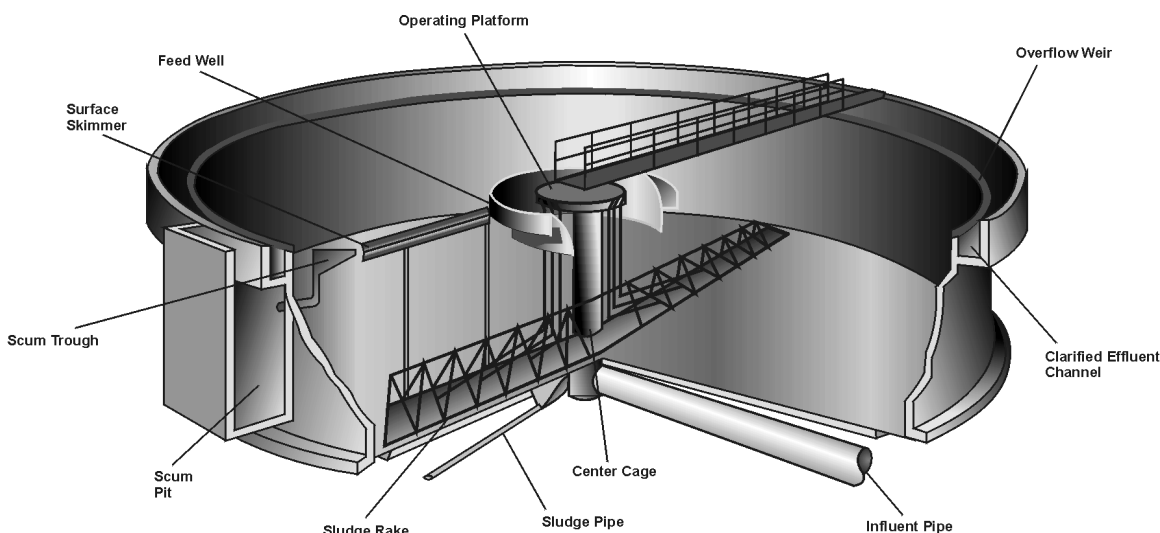
Figure 8-15. Center-Feed Rim Flow Clarifier

8.5.1.2   Microfiltration for Solids Removal

Microfiltration is an alternative to conventional gravity clarification after chemical precipitation. Microfiltration is a membrane-based process used to separate small suspended particles based on size and shape. Water and small solute species pass under pressure through a membrane and are collected as permeate while larger particles such as precipitated and flocculated metal hydroxides are retained by the membrane and are recovered as concentrate. Microfiltration is similar to ultrafiltration (Section 8.4.5.4) but has a larger pore size.

Microfiltration removes materials ranging from 0.1 to 1.0 microns (e.g., colloidal particles, heavy metal particulates and their hydroxides). Most microfiltration membranes consist of homogeneous polymer material. The transmembrane pressure required for microfiltration typically ranges between 3 to 50 psi, depending on membrane pore size.

Microfiltration produces a concentrated suspended solid slurry that typically goes to dewatering equipment such as a sludge thickener or a filter press. The permeate can either be treated further to adjust the pH or be discharged, depending on local and state requirements. Figure 8-5 shows a typical membrane filtration system.

The microfiltration system includes: pumps and feed vessels; piping or tubing; monitoring and control units for temperature, pressure, and flow rate; process and cleaning tanks; and membranes. Membranes are designed specifically to handle various waste stream parameters, including temperature, pH, and chemical compatibility. Different types of membranes are available, including hollow fiber, tubular, flat plate, and spiral wound. The configuration selected for a particular facility depends on the type of application. For example, tubular membranes commonly separate suspended solids, whereas spiral wound membranes

separate oils from water. Microfiltration is more expensive than conventional gravity clarification. Membranes must be cleaned periodically to prevent fouling and ensure effective treatment.

8.5.1.3   Optimization of Existing Chemical Precipitation Treatment System

Facilities can optimize the performance of an existing chemical precipitation and clarification system using a variety of techniques such as adding equalization prior to treatment, conducting jar testing to optimize treatment chemistry, upgrading control systems, and providing operator training.

Equalization

Equalization is simply the damping of flow and concentration variations to achieve a constant or nearly constant wastewater treatment system loading (8). Equalization improves treatment performance by providing a uniform hydraulic loading to clarification equipment, and by damping mass loadings, which improves chemical feed control and process reliability. MP&M facilities implement equalization by placing a large collection tank ahead of the treatment system. All process water and rinse water entering this tank are mixed mechanically and then pumped or allowed to gravity flow to the treatment system at a constant rate.   The size (volume) of the tank depends on the facility flow variations throughout the day. Operating data collected during MP&M sampling episodes indicate hydraulic residence times for equalization tanks average 4 to 6 hours.

Jar Testing

The purpose of jar testing is to optimize treatment pH, flocculant type and dosage, the need for coprecipitants such as iron, and solids removal characteristics. Facilities should conduct jar testing on a sample of their actual wastewater to provide reliable information.

Control System Upgrades

Typical treatment system controls at MP&M facilities includes pH and ORP controllers on alkaline chlorination systems for cyanide destruction, pH controllers on chemical precipitation systems, flow and level monitoring equipment on equalization tanks, and solonoid valves and metering pumps on chemical feed systems to provide accurate treatment chemical dosing. A number of MP&M facilities have computer hardware and software to monitor and change treatment system operating parameters. For a number of MP&M facilities, upgrading control equipment may reduce both pH and ORP swings caused by excess chemical dosing, resulting in consistent effluent metals concentrations.

Operator Training

Having operators trained in both the theory and practical application of wastewater treatment is key to ensuring the systems are operating at their best. Many MP&M facilities send their operators to off-site training centers while others bring consultants familiar with their facility's operations and wastewater treatment system to the facility to train operators. Some of the basic elements of an operator training course should include (1):

- An explanation of the need for wastewater treatment, which emphasizes the benefits to employees and the community;

- An emphasis on management's commitment to environmental stewardship;

- An explanation of wastewater treatment terminology in simple terms;

- An overview of the environmental regulations that govern the facility's wastewater discharges;

- A simple overview of wastewater treatment chemistry;

- Methods that can optimize treatment performance (e.g., how to conduct jar testing);

- The test methods or parameters used to verify the system is operating properly (e.g., control systems); and

- The importance of equipment maintenance to ensure the system is operating at its maximum potential.

First-time training for new operators may require 4 to 5 days of classroom and hands-on study. Experienced MP&M wastewater treatment operators should consider attending at least 1 day of refresher training per year to update themselves on the chemistry and to learn about new equipment on the market that may help their system's performance.

8.5.2 Oil Removal

Operations such as machining and grinding, disassembly of oily equipment, and cleaning can generate wastewater containing organic machining coolants, hydraulic oils, and lubricating oils. In addition, shipbuilding facilities may commingle oily bilge water with wastewater from other shore-side operations, resulting in a mixed oily wastewater. Information collected during MP&M site visits, sampling episodes, and from the MP&M detailed surveys showed a variety of methods to treat oily wastewater. The primary treatment technologies are

emulsion breaking and gravity flotation, emulsion breaking and DAF, and ultrafiltration. Section 8.4 discusses these technologies.

8.5.3   Polishing Technologies

Polishing systems remove small amounts of pollutants that may remain in the effluent after treatment using technologies such as chemical precipitation and gravity clarification. These systems also can act as a temporary measure to prevent pollutant discharge should the primary solids removal system fail due to a process upset or catastrophic event. The following are descriptions of end-of-pipe polishing technologies that are applicable to MP&M facilities.

8.5.3.1   Multimedia Filtration

Sand filtration and multimedia filtration systems typically remove small amounts of suspended solids (metal precipitates) entrained in effluent from gravity clarifiers. Sand and multimedia polishing filters usually are designed to remove 90 percent or greater of all filterable suspended solids 20 microns or larger at a maximum influent concentration of 40 mg/L. Wastewater is pumped from a holding tank through the filter. The principal design factor for the filter is the hydraulic loading. Typical hydraulic loadings range between 4 and 5 gpm/ft^2 (9). Sand and multimedia filters are cleaned by backwashing with clean water. Backwashing is timed to prevent breakthrough of the suspended solids into the effluent. Figure 8-16 shows a diagram of a multimedia filtration system.
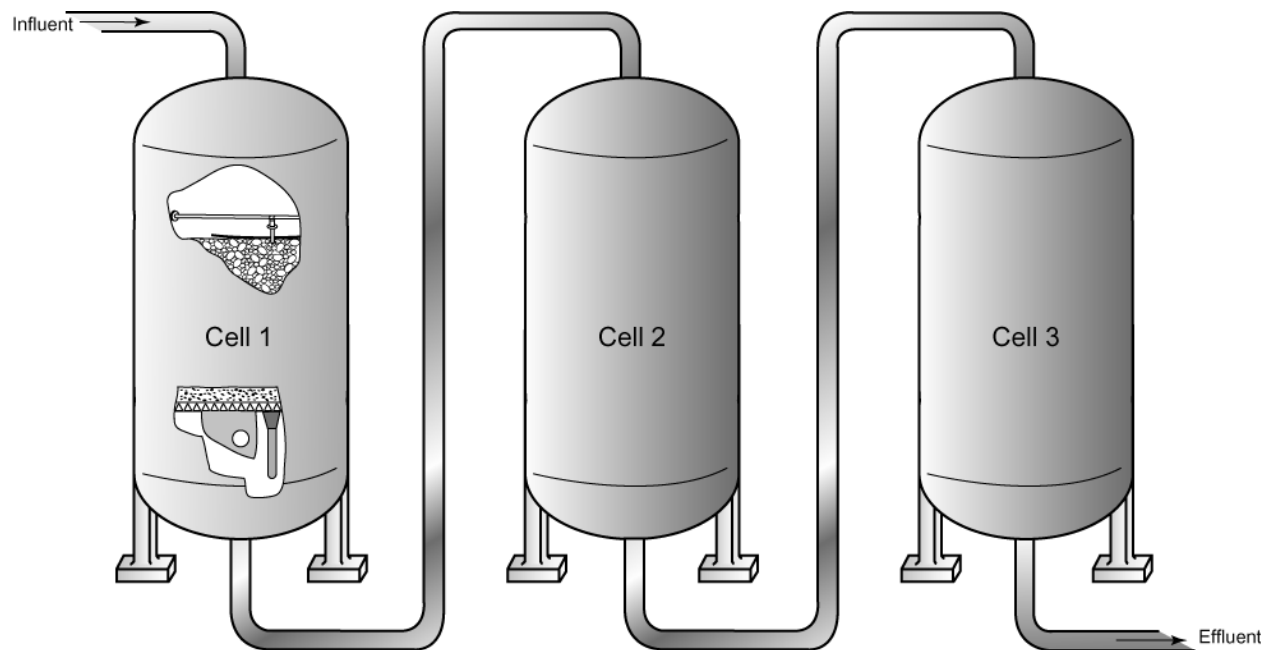

Figure 8-16. Multimedia Filtration System

8.5.3.2   Activated Carbon Adsorption

Activated carbon adsorption removes dissolved organic compounds from wastewater. Some MP&M facilities use carbon adsorption to polish effluent from ultrafiltration systems treating oily wastewater. During adsorption, molecules of a dissolved compound adhere to the surface of an adsorbent solid. Activated carbon is an excellent adsorption medium due to its large internal surface area, generally high attraction to organic pollutants, and hydrophobic nature (i.e., water will not occupy bonding sites and interfere with the adsorption of pollutants). Pollutants in the wastewater bond on the activated carbon grains until all the surface bonding sites are occupied. At that point, the carbon is considered to be "spent." Spent carbon requires regeneration; regenerated carbon has a reduced adsorption capacity compared to fresh carbon. After several regenerations, the carbon is disposed of.

The carbon fits in granular carbon system vessels, forming a "filter" bed. Vessels are usually circular for pressure systems and rectangular for gravity flow systems. For wastewater treatment, activated carbon typically is packed into one or more filter beds or columns; a typical treatment system consists of multiple filter beds in series. Wastewater flows through the filter beds and comes in contact with all portions of the activated carbon. The activated carbon in the upper portion of the column is spent first (assuming flow is downward), and progressively lower regions of the column are spent as the adsorption zone moves down the unit. When pollutant concentrations at the bottom of the column begin to increase above acceptable levels, the entire column is considered spent and must be regenerated or removed.

8.5.3.3   Reverse Osmosis

Reverse osmosis is a membrane separation technology used by MP&M facilities as an in-process step or as an end-of-pipe treatment. Section 8.2.8.2 discusses in-process reverse osmosis. In an end-of-pipe application, reverse osmosis typically recycles water and reduces discharge volume rather than recovers chemicals. The effluent from a conventional treatment system generally has a TDS concentration unacceptable for most rinsing operations, and cannot be recycled. Reverse osmosis with or without some pretreatment can replace TDS concentrations, and the resulting effluent stream can be used for most rinsing operations.

8.5.3.4   Ion Exchange

Ion exchange is both an in-process metals recovery and recycle and end-of-pipe polishing technology. Section 8.2.8.1 discusses in-process ion exchange. This technology generally uses cation resins to remove metals but sometimes uses both cation and anion columns. The regenerant from end-of-pipe ion exchange is not usually amenable to metals recovery as it typically contains multiple metals at low concentrations.

8.5.4   Sludge Handling

This subsection discusses the following sludge-handling technologies:

- Gravity thickening;
- Pressure filtration;
- Sludge drying; and
- Vacuum filtration.

8.5.4.1   Gravity Thickening

Gravity thickening is a physical liquid-solid separation technology used to dewater wastewater treatment sludge. Sludge feeds from a primary settling tank or clarifier to a thickening tank, where gravity separates the supernatant (liquid) from the sludge, increasing the sludge density. The supernatant returns to the primary settling tank or the head of the treatment system for further treatment. The thickened sludge that collects on the bottom of the tank is pumped to additional dewatering equipment or contract hauled for disposal. Figure 8-17 shows a diagram of a gravity thickener.

Figure 8-17.   Gravity Thickening
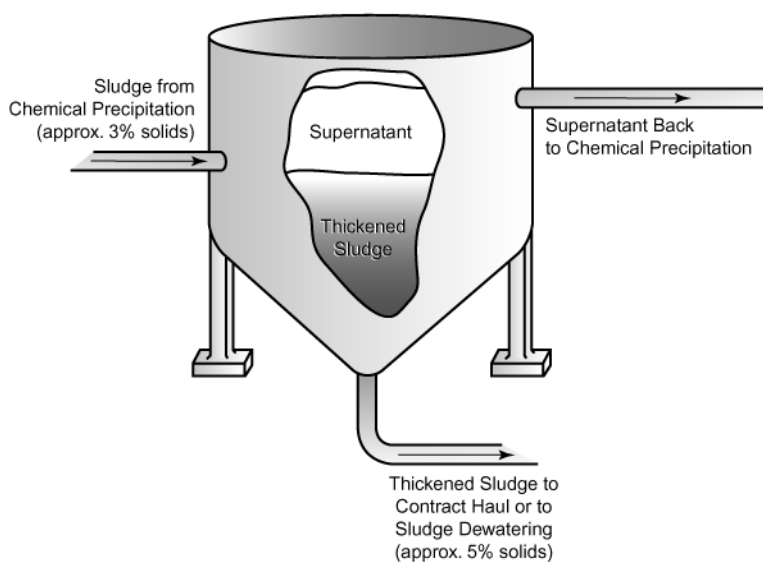
Facilities where the sludge is to be further dewatered by a mechanical device, such as a filter press, generally use gravity thickeners. Increasing the solids content in the thickener substantially reduces capital and operating costs of the subsequent dewatering device and also reduces the hauling cost. This process is potentially applicable to any MP&M facility that generates sludge.

8-60

8.5.4.2   Pressure Filtration

The filter press is the most common type of pressure filtration used at MP&M facilities for dewatering wastewater treatment sludges. A filter press consists of a series of parallel plates pressed together by a hydraulic ram (older models may have a hand crank), with cavities between the plates. Figure 8-18 shows a diagram of a plate-and-frame filter press. The filter press plates are concave on each side to form cavities and are covered with a filter cloth. At the start of a cycle, a hydraulic pump clamps the plates tightly together and a feed pump forces a sludge slurry into the cavities of the plates. The liquid (filtrate) escapes through the filter cloth and grooves molded into the plates and is forced by the pressure of the feed pump (typically around 100 psi) to a discharge port. The filter cloth retains the solids, which remain in the cavities. This process continues until the cavities are packed with sludge solids. Some units use an air blow-down manifold at the end of the filtration cycle to drain remaining liquid from the system, further drying the sludge. The pressure releases and the plates separate. The sludge solids or cake is loosened from the cavities and falls into a hopper or drum. A plate filter press can produce a sludge cake with a dryness of approximately 20 to 30 percent solids for metal hydroxides precipitated with sodium hydroxide, and 30 to 40 percent solids for metal hydroxides precipitated with calcium hydroxide. Filter presses are available in a very wide range of capacities (0.6 ft^3 to 20 ft^3). A typical operating cycle is from 4 to 8 hours, depending on the dewatering characteristics of the sludge. Units are usually sized based on one or two cycles per day.
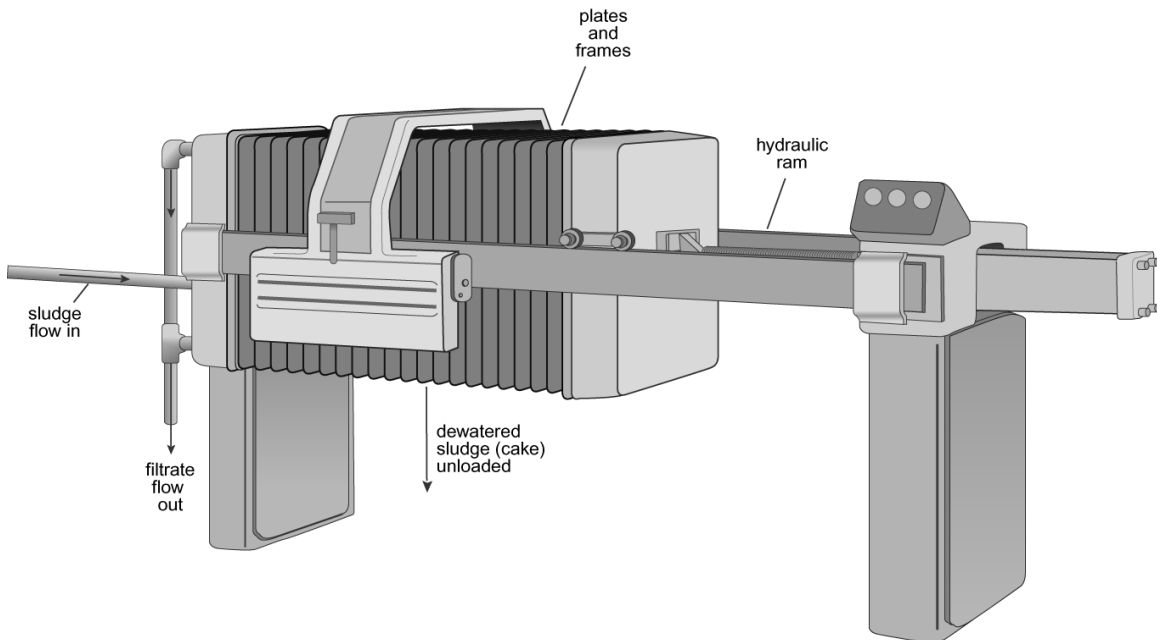

Figure 8-18. Plate-and-Frame Filter Press

8.5.4.3   Vacuum Filtration

Some MP&M facilities conduct vacuum filtration to reduce the water content of metal hydroxide sludge. These MP&M facilities generally use cylindrical drum vacuum filters. The filters on these drums typically are either made of natural or synthetic fibers, or a wire-mesh fabric. The drum dips into a vat of sludge and rotates slowly. A vacuum inside the drum draws sludge to the filter. Water is drawn through the filter to a discharge port, and the dewatered sludge is scraped from the filter. Because dewatering sludge with a vacuum filter is relatively expensive per kilogram of water removed, the liquid sludge is frequently gravity-thickened prior to vacuum filtration. Figure 8-19 shows a typical rotary vacuum filter. Municipal treatment plants and a wide variety of industries frequently use vacuum filters. Larger facilities more commonly use this technology, as they may have a gravity thickener to double the solids content of clarifier sludge before vacuum filtering. Often facilities apply a precoat to inhibit filter blinding.
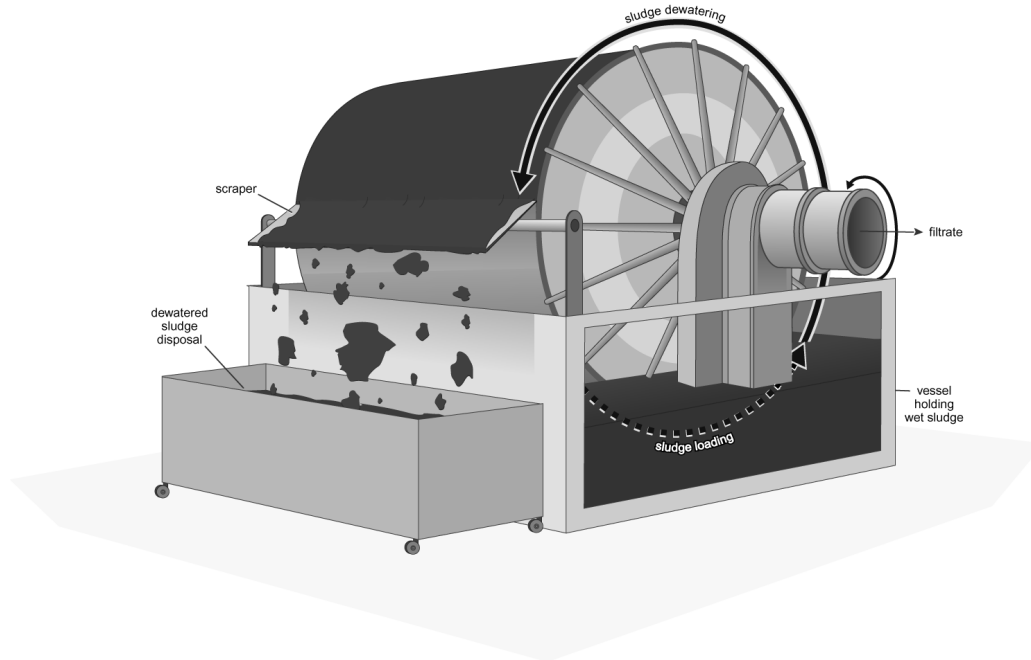
Figure 8-19. Rotary Vacuum Filter

Maintenance of vacuum filters involves cleaning or replacing the filter media, drainage grids, drainage piping, filter parts, and other parts. Since maintenance time may be as high as 20 percent of total operating time, facilities may maintain one or more spare units. If this technology is used intermittently, the facility may drain and wash the filter equipment each time it is taken out of service.

8.5.4.4 Sludge Drying

Wastewater treatment sludges are often hauled long distances to disposal facilities. The transportation and disposal costs depend mostly on the volume and weight of sludge, which is directly related to its water content. Therefore, many MP&M facilities use sludge drying equipment following dewatering to further reduce the volume and weight of the sludge. The solids content of the sludge dewatered on a filter press usually ranges from 20 to 40 percent. Drying equipment can produce a waste material with a solids content of approximately 90 percent.

There are several design variations for sludge drying equipment. A commonly used system consists of an auger or conveyor system to move a thin layer of sludge through a drying region and discharge it into a hopper. Various heat sources including electric, electric infrared, steam, and gas are used for sludge drying. Some continuous units are designed such that the sludge cake discharged from a filter press drops into the feed hopper of the unit, making the overall dewatering process more automated. System capacities range from less than 1 ft^3/hr to more than 20 ft^3/hr of feed. Sludge drying equipment requires an air exhaust system due to the fumes generated during drying.

8.6 References

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9.0   TECHNOLOGY OPTIONS

This section presents the technology options evaluated by EPA as the basis for the final MP&M effluent limitations guidelines and standards. It also describes EPA's rationale for selecting the technology options for the final rule. EPA used the options presented in this section as the basis for evaluating Best Practicable Control Technology Currently Available (BPT), Best Conventional Pollutant Control Technology (BCT), Best Available Technology Economically Achievable (BAT), New Source Performance Standards (NSPS), Pretreatment Standards for Existing Sources (PSES), and Pretreatment Standards for New Sources (PSNS).

EPA is promulgating performance-based limitations and standards for the Oily Wastes Subcategory to control direct discharges. These limitation and standards do not require the use of any particular pollution prevention or wastewater treatment technology. Rather, a facility may use any combination of pollution prevention and wastewater treatment technology to comply with the limitations. Direct dischargers must also comply with NPDES regulations (40 CFR 122).

Section 9.1 summarizes the methodology EPA used to select the technologies included in the options. Sections 9.2 through 9.9 describe the technology options evaluated for the final effluent limitations guidelines and standards for each subcategory for each of the regulatory levels of control. Section 9.10 summarizes the options for each subcategory considered and selected in developing the effluent limitations and standards, and Figures 9-1 through 9-6 (at the end of this section) present schematic diagrams of the options.

9.1   Technology Evaluation Methods

Facilities performing proposed MP&M operations generate wastewater containing oils, organic pollutants, cyanide, hexavalent chromium, complexed metals, and dissolved metals.[1] The technology options considered for the final rule consist of pollution prevention and wastewater treatment technologies designed to reduce or eliminate the generation or discharge of pollutants from facilities performing proposed MP&M operations. EPA identified these technologies from responses to the MP&M detailed and screener surveys, MP&M site visits and sampling episodes, and technical literature. EPA then grouped the most common technologies according to the type of wastewater treated (e.g., oily wastewater, metal-bearing wastewater, cyanide-bearing wastewater), and also by source reduction and pollution prevention technologies, recycling technologies, and end-of-pipe treatment technologies. Tables 8-1 through 8-3 in Section 8.0 show the in-process and end-of-pipe treatment used by industry as reported in industry surveys.

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[1]Note: EPA evaluated a number of unit operations for the May 1995 proposal, January 2001 proposal, and June 2002 NODA (see Tables 4-3 and 4-4). However, EPA selected a subset of these unit operations for regulation in the final rule (see Section 1.0). For this section, the term "proposed MP&M operations" means those operations evaluated for the two proposals, NODA, and final rule. The term "final MP&M operations" means those operations defined as "oily operations" (see Section 1.0, 40 CFR 438.2(f), and Appendix B to Part 438) and regulated by the final rule.

EPA considered a technology to be demonstrated in the industry if the technology effectively treated wastewater from proposed MP&M operations and if EPA observed the technology during at least one MP&M site visit or at least one survey respondent reported using the technology. EPA evaluated the performance of each technology in terms of percent removal and final effluent concentration using analytical data available from MP&M sampling episodes, discharge monitoring reports and periodic compliance reports, previous effluent guidelines data collection efforts, and quantitative and qualitative assessments from engineering site visits, comment submittals, and literature.

EPA evaluated several technology options for direct dischargers in the subcategories listed in the January 2001 proposal (i.e., General Metals, Metal Finishing Job Shops, Printed Wiring Board, Non-Chromium Anodizing, Steel Forming and Finishing, Oily Wastes, Railroad Line Maintenance, and Shipbuilding Dry Dock).

9.2 General Metals Subcategory

EPA is not revising or establishing any limitations or standards for facilities that would have been subject to this subcategory. Such facilities will continue to be regulated by the General Pretreatment Standards (Part 403), local limits, permit limits, and Parts 413 and/or 433, as applicable.

9.2.1 Best Practicable Control Technology Currently Available (BPT)

The following discussion describes the technology options considered for the proposed General Metals Subcategory. Facilities in this proposed subcategory generate metal-bearing wastewater but may also generate some oily wastewater (see Section 6.0).

Option 1

Option 1 includes segregation and preliminary treatment of oily wastewater, cyanide-bearing wastewater, hexavalent chromium-bearing wastewater, and complexed metal-bearing wastewater, followed by chemical precipitation using either sodium hydroxide or lime, sedimentation using a clarifier, and sludge removal using gravity thickening and a filter press. Segregation of wastewater and subsequent preliminary treatment allows for the most efficient, effective, and economical means of removing pollutants in certain wastewater streams. These streams contain pollutants (e.g., oil and grease, cyanide, hexavalent chromium, chelated metals, and organic solvents) that can inhibit the performance of chemical precipitation and sedimentation treatment, while increasing the overall treatment costs. For example, if a facility segregates its oil-bearing wastewater from its metal-bearing wastewater, then the facility can design an oil removal treatment technology based on only the oily waste flow volume and not on the combined metal-bearing and oil-bearing wastewater flow, decreasing the size of the overall treatment system. Treatment chemical costs are also reduced because of the reduced volume. Preliminary treatment technologies for these types of wastewater streams are described below.

(see Section 5.0 and Appendix C for a more detailed description of each of these wastewater streams).

- **Oil-Bearing Wastewater**. Alkaline cleaning wastewater and water-based metal-working fluids (e.g., machining and grinding coolants) typically contain significant amounts of oil and grease. These wastewater streams require preliminary treatment to remove oil and grease and organic pollutants. Option 1 includes a preliminary treatment step for these wastewaters consisting of chemical emulsion breaking followed by gravity separation of oil and water (oil/water separator or gravity flotation).

- **Cyanide-Bearing Wastewater**. The industry generates several types of wastewater that may contain significant amounts of cyanide, such as electroplating and cleaning wastewater. Option 1 includes a preliminary treatment step for these wastewaters consisting of alkaline chlorination with sodium hypochlorite.

- **Hexavalent Chromium-Bearing Wastewater**. The industry generates several types of wastewater that contain hexavalent chromium, usually from acid treatment, anodizing, conversion coating, and electroplating. Because hexavalent chromium does not form an insoluble hydroxide, this wastewater requires chemical reduction of the hexavalent chromium to trivalent chromium prior to chemical precipitation and sedimentation. Trivalent chromium forms an insoluble hydroxide and is treated by chemical precipitation and sedimentation. Option 1 includes a preliminary treatment step for these wastewaters consisting of chromium reduction using sodium metabisulfite.

- **Chelated Metal-Bearing Wastewater**. Electroless plating and some cleaning operations generate wastewater that contains significant amounts of chelated metals. This wastewater requires chemical reduction to break the metal-chelate bond or reduce the metal-chelate complex to an insoluble state so that it can be removed during chemical precipitation. Option 1 includes a preliminary treatment step for these wastewaters consisting of chemical reduction using sodium borohydride, dithiocarbamate, hydrazine, or sodium hydrosulfite.

- **Organic Solvent-Bearing Wastewater**. Option 1 also includes contract hauling of solvent degreasing wastewater, where applicable. Based on the MP&M surveys and site visits, most solvent degreasing operations that use organic solvents (e.g., 1,1,1-trichloroethane, trichloroethene) are contract hauled for off-site recycling. Some facilities performing proposed MP&M operations reported using organic solvent/water mixtures or rinses

following organic solvent degreasing. EPA found contract hauling of this wastewater to be the most common disposal method for these sites.

After pretreatment of the applicable segregated streams, the Option 1 technology basis is chemical precipitation and gravity clarification. Chemical precipitation adjusts the pH of the wastewater with alkaline chemicals such as lime (calcium hydroxide) or caustic (sodium hydroxide) or acidic chemicals (such as sulfuric acid) to produce insoluble metal hydroxides. This step is followed by a gravity settling process in a clarifier to remove the precipitated and flocculated metal hydroxides. Sludge is then thickened in a gravity-thickening unit. The sludge is then sent to a filter press used to remove excess wastewater, which is generally recycled back to the clarifier.

The technology components that many facilities performing proposed MP&M operations currently use are equivalent to those described for Option 1. Differences in the level of performance (i.e., effluent limitations) between current discharges and Option 1 derive from improvements in operation and control of process operations and pollutant control technology. EPA's technical database developed for this rule, including industry survey, site visit, and sampling information collected during the period from 1989 through 2001, demonstrate significant progress by the industry in reducing pollutants in wastewater discharges beyond the existing regulatory standards. For example, sites are moving toward greater implementation of pollution prevention and water reduction, including progression to zero discharge when possible. In addition, improvements in treatment controls allow for more automated controls, which leads to more consistent process operation and wastewater treatment. Finally, advances in wastewater treatment chemicals also result in higher treatment efficiencies.

Option 2

Option 2 builds on Option 1 by adding the following in-process pollution prevention, recycling, and water conservation methods that allow for recovery and reuse of materials:

- Two-stage countercurrent cascade rinsing for all flowing rinses;

- Centrifugation and recycling of painting water curtains; and

- Centrifugation, pasteurization, and recycling of water-soluble machining coolants.

Option 2S

Option 2S includes the technologies that compose Option 2 plus a sand filter after the clarifier to further remove residual suspended solids from chemical precipitation and clarification effluent.

Option 3

In Option 3, an ultrafilter replaces the Option 1 chemical emulsion breaking and oil/water separator to remove oil and grease, and a microfilter replaces the Option 1 clarifier.

Option 4

Option 4 includes the technologies in Option 3 plus the in-process flow control and pollution prevention technologies described in Option 2, allowing recovery and reuse of materials along with water conservation.

Best Professional Judgment (BPJ) to Part 433 Option

EPA also considered transferring limitations from existing Metal Finishing effluent guidelines (40 CFR 433) to the General Metals Subcategory. The technology basis for Part 433 includes the following: (1) segregation of wastewater streams; (2) preliminary treatment steps as necessary (including oils removal using chemical emulsion breaking and oil/water separation, alkaline chlorination for cyanide destruction, reduction of hexavalent chromium, and chelation breaking); (3) chemical precipitation using sodium hydroxide; (4) sedimentation using a clarifier; and (5) sludge removal (i.e., gravity thickening and filter press).

Option Selection Discussion

As discussed in the 2001 proposal (see 66 FR 451), EPA dropped Options 1 and 3 from further consideration because Options 2 and 4, respectively, cost less and provided greater pollutant removals. After proposal, EPA also dropped Option 4 from further consideration for the final rule because of its increased cost and lack of significant additional pollutant removals beyond Option 2. In addition, comments submitted on the proposed rule questioned the completeness of EPA's database on microfiltration (Option 4), noting that EPA transferred limitations for several pollutants from the Option 2 technology based on lack of data.

EPA dropped Option 2S from further consideration for the final rule for the reasons outlined in the 2002 Notice of Data Availability (NODA) (67 FR 38767). First, Option 2S results in greatly increased cost and minimal increased pollutant removals beyond Option 2. Second, EPA believes, after incorporating additional treatment performance data and revising the statistical methodology used for calculating numerical limitations (see Section 10.0), the Option 2 limitations are consistently achievable without adding a sand filter. Therefore, for the final rule, EPA considered Option 2 and "BPJ to Part 433 Option" as the basis for limitations for BPT for the General Metals Subcategory. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant removals for Option 2.

EPA proposed to establish BPT limitations for existing direct dischargers in the General Metals Subcategory based on the Option 2 technology. EPA evaluated the cost of achieving effluent reductions, pollutant reductions, and the economic achievability of compliance

with BPT limitations based on the Option 2 technology and the level of the pollutant reductions resulting from compliance with such limitations. EPA has decided not to establish BPT limitations for existing direct dischargers in the proposed General Metals Subcategory. The 2001 proposal also contains detailed discussions on why EPA rejected BPT limitations based on other BPT technology options (see 66 FR 452). The information in the rulemaking record for the final rule provides no basis for EPA to change this conclusion.

Those facilities potentially regulated in the General Metals Subcategory include facilities that are currently subject to effluent limitations guideline regulation under 40 CFR 433 as well as facilities not currently subject to national regulation. Approximately 263 of the 266 existing General Metals direct dischargers (estimated from survey weights for 31 surveyed facilities) are currently covered by the Metal Finishing effluent guidelines at Part 433. The remaining three facilities (estimated from a survey weight for one surveyed facility) are currently directly discharging metal-bearing wastewaters (e.g., salt bath descaling) but are not covered by existing Metal Finishing effluent guidelines. EPA's review of discharge monitoring data and unit operations for this surveyed non-433 General Metals facility (with a survey weight of approximately three) indicates that this facility is already achieving Part 433 limitations because this facility has discharges that closely mirror those required by Part 433.

The facilities that are currently subject to Part 433 regulations and those facilities achieving Part 433 discharge levels, in most cases, have already installed effective pollution control technology that includes many of the components of the Option 2 technology. Approximately 30 percent of the direct discharging facilities in the General Metals Subcategory currently use chemical precipitation followed by a clarifier. Further, EPA estimates that compliance with BPT limitations based on the Option 2 technology would result in no closures of the existing direct dischargers in the General Metals Subcategory. EPA also notes that the adoption of this level of control would also reduce the pollutants discharged into the environment by facilities in this subcategory. For facilities in the General Metals Subcategory at Option 2, EPA estimates an annual compliance cost of $23.7 million (2001$). Using the method described in Section 12.0 to estimate baseline pollutant loadings, EPA estimates Option 2 pollutant removals of 417,477 pounds of conventional pollutants and 33,716 pounds of priority metal and organic pollutants from current discharges into the Nation's waters.

Evaluated under its traditional yardstick, EPA calculated that the effluent reductions are achieved at a cost of $18.1/pound-pollutant removed (2001$) for the General Metals Subcategory at Option 2. To estimate all pounds of pollutant removed by Option 2 technology for direct dischargers in the General Metals Subcategory, EPA used the revised method described in Section 12.0 to estimate baseline pollutant loadings as the sum of chemical oxygen demand (COD) pounds removed plus the sum of all metals pounds removed. EPA used the combination of COD pounds removed plus the sum of all metals pounds removed to avoid any significant double counting of pollutants.

As previously stated, EPA received many comments on its estimation of baseline pollutant loadings and reductions for the various options presented in the January 2001 proposal.

In response to these comments, EPA solicited comment in the June 2002 NODA on alternative methods to estimate baseline pollutant loadings. Commentors on the NODA were generally supportive of EPA's alternative methods to estimate baseline pollutant loadings. In particular, commentors noted that more accurate estimates of baseline pollutant loadings could be achieved by using DMR data. In response to these NODA comments, EPA combined the alternative methods in the NODA into the EPA Costs & Loadings Model for the final rule (see Sections 11.0 and 12.0).

EPA also received comment on the parameter or parameters it should use for estimating total pounds removed by the selected technology option. EPA selected the sum of COD and all metals pounds removed for the final rule to compare effluent reductions and compliance costs. This approach avoided any significant double counting of pollutants and also provided a reasonable estimate of total pounds removed by Option 2 for the General Metals Subcategory. Option 2 technology segregates wastewaters into at least five different waste streams, each of which have one or two treatment steps. For example, segregated oily wastewaters have two treatment steps under Option 2 technology as they are first treated by chemical emulsion breaking-oil/water separation and then by chemical precipitation and sedimentation. These segregated wastestreams can be loosely grouped together as either oily wastewaters or metal-bearing wastewaters. EPA's use of COD pounds removed for Option 2 technology generally represents the removal of pollutants from the segregated oily wastewaters. EPA's use of total metals pounds removed for Option 2 technology generally represents the removal of pollutants from the segregated metal-bearing wastewaters.

EPA also considered alternative parameters for calculating total pounds removed by Option 2 for the comparison of effluent reductions and compliance costs for the General Metals Subcategory. In particular, EPA calculated a ratio of less than $14/pound-pollutant removed (2001$) for the General Metals Subcategory at Option 2 when EPA used the highest set of pollutants removed per facility with no significant double counting of pollutants (i.e., highest per facility pollutant removals of: (1) COD plus total metals; (2) oil and grease (as HEM) plus total metals; or (3) oil and grease (as HEM) plus total suspended solids (TSS)). EPA used the highest per facility pollutant removals as a confirmation of its primary method for calculating baseline pollutant loadings (see Section 12.0) and Option 2 for General Metals Subcategory.

Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the June 2002 NODA and in Sections 11.0 and 12.0, EPA has decided not to adopt BPT limitations based on Option 2 technology. A number of factors supports EPA's conclusion that BPT limitations based on Option 2 technology do not represent effluent reduction levels attainable by the best practicable technology currently available. As previously noted, a substantial number of facilities that would be subject to limitations as General Metals facilities are already regulated by BPT/BAT Part 433 limitations and other facilities are *de facto* Part 433 facilities if characterized by their discharges. Thus, establishing BPT limitations for a new General Metals Subcategory would effectively revise existing BPT/BAT limitations with respect to those facilities. In this case, EPA felt that since the Agency is revising BPT/BAT limitations for a significant portion of an industry, it should further review the effluent reductions achieved,

and corresponding costs, for Option 2 technology. Such an examination shows that, while the Option 2 technology would remove additional pollutants at costs in the middle of the range EPA has traditionally determined are reasonable, the costs of the additional removals of toxic pollutants are substantially greater. In developing the final rule, EPA determined that, where a substantial portion of a subcategory is already subject to effluent limitations guidelines that achieve significant removal, the Agency should not promulgate the proposed BPT limitations because the limitations would achieve additional toxic removals at a cost ($1,000/pound equivalent (PE) in 1981$) substantially greater than that EPA has typically imposed for BAT technology in other industries (generally less than $200/PE in 1981$).

EPA also considered transferring limitations from existing Metal Finishing effluent guidelines (40 CFR 433) to the General Metals Subcategory. The technology basis for Part 433 includes the following: (1) segregation of wastewater streams; (2) preliminary treatment steps as necessary (including oils removal using chemical emulsion breaking and oil/water separation, alkaline chlorination for cyanide destruction, reduction of hexavalent chromium, and chelation breaking); (3) chemical precipitation using sodium hydroxide; (4) sedimentation using a clarifier; and (5) sludge removal (i.e., gravity thickening and filter press).

Approximately 99 percent of the existing direct dischargers in the General Metals Subcategory are currently covered by the existing Metal Finishing effluent guidelines. The remaining 1 percent (an estimated three facilities nationwide based on the survey weight associated with one surveyed facility) are currently permitted to discharge metal-bearing wastewaters but are not covered by the existing Metal Finishing effluent guidelines. EPA's review of discharge monitoring data and unit operations for this surveyed non-433 General Metals facility (with a survey weight of approximately three) indicates that this facility is subject to permit limitations established on a BPJ basis that are equivalent or more stringent than Part 433 limitations. Transferring limitations from existing Metal Finishing effluent guidelines would likely result in no additional pollutant load reductions. Therefore, based on the lack of additional pollutant removals that are estimated, EPA is not promulgating BPT limitations transferred from existing Metal Finishing effluent limitations guidelines for the General Metals Subcategory.

EPA is not revising or establishing BPT limitations for any facilities in this subcategory. Direct dischargers in the General Metals Subcategory will remain regulated by permit limits and Part 433, as applicable.

9.2.2   Best Conventional Pollutant Control Technology (BCT)

In deciding whether to adopt more stringent limitations for BCT than BPT, EPA considers whether there are technologies that achieve greater removals of conventional pollutants than those adopted for BPT, and whether those technologies are cost-reasonable under the standards established by the CWA. EPA generally refers to the decision criteria as the "BCT cost test." For a more detailed description of the BCT cost test and details of EPA's analysis, see Chapter 4 of the Economic, Environmental, and Benefits Analysis of the Final Metal Products & Machinery Rule (EEBA) (EPA-821-B-03-002).

As EPA is not establishing any BPT limitations for the General Metals Subcategory, EPA did not evaluate any technologies for the final rule that can achieve greater removals of conventional pollutants. Consequently, EPA is not establishing BCT limitations for the General Metals Subcategory.

9.2.3   Best Available Technology Economically Achievable (BAT)

EPA proposed to establish BAT limitations for existing direct dischargers in the General Metals Subcategory based on the Option 2 technology. As discussed in Section 9.2.1, EPA has decided not to establish BPT limitations based on Option 2 technology. For the same reasons, EPA is not establishing BAT limitations based on the same technology. EPA evaluated the cost of effluent reductions, pollutant reductions, and the economic achievability of compliance with BAT limitations based on the Option 2 technology.

Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and in Sections 11.0 and 12.0, EPA determined that the costs of Option 2 are disproportionate to the toxic pollutant reductions (measured in PE). The cost of achieving the effluent reduction (in 1981$) for Option 2 for direct dischargers in the General Metals Subcategory is over $1,000/PE removed (see the EEBA and Section 26.0 of the rulemaking record, DCN 37900, for a discussion of the cost-effectiveness analysis). The costs associated with this technology are, as previously noted, substantially greater than the level EPA has traditionally determined are associated with available toxic pollutant control technology. EPA has determined that Option 2 technology is not the best available technology economically achievable for existing direct dischargers in the General Metals Subcategory. Therefore, EPA is not revising or establishing BAT limitations for this subcategory based Option 2 technology.

EPA also considered transferring BAT limitations from existing Metal Finishing effluent guidelines (40 CFR 433.14) to the General Metals Subcategory (see "BPJ to Part 433 Option" in Section 9.2.1). EPA reviewed existing General Metals facilities and found that all are currently achieving Part 433 BAT limitations. Transferring BAT limitations from existing Metal Finishing effluent guidelines would likely result in no additional pollutant load reductions and minimal incremental compliance costs (see Section 9.2.1). Therefore, based on the lack of additional pollutant removals that are estimated, EPA is not promulgating BAT limitations transferred from existing Metal Finishing effluent limitations guidelines for the General Metals Subcategory.

EPA is not revising or establishing BAT limitations for any facilities in this subcategory. Direct dischargers in the General Metals Subcategory will remain regulated by permit limits and Part 433, as applicable.

9.2.4 New Source Performance Standards (NSPS)

EPA proposed NSPS for the General Metals Subcategory based on Option 4 technology (see Section 9.2.1). Option 4 technology is similar to Option 2 (including Option 2 flow control and pollution prevention) but includes oils removal using ultrafiltration and solids separation by a microfilter (instead of a clarifier). Commentors stated that EPA had under-costed the Option 4 technology and that the compliance costs would be a barrier to entry for new facilities. In addition, commentors questioned the completeness of EPA's database on microfiltration, noting that EPA transferred standards for several pollutants from the Option 2 technology, based on lack of data. EPA reviewed its database for the Option 4 technology and agrees that its microfiltration database is insufficient to support a determination that the Option 4 limitations are technically achievable.

EPA also evaluated setting General Metals NSPS based on the Option 2 technology and assessed the financial burden to new General Metals direct dischargers. Specifically, EPA's 'barrier-to-entry' analysis identified whether General Metals NSPS based on the Option 2 technology would pose sufficient financial burden as to constitute a material barrier to entry of new General Metals establishments into the MP&M Point Source Category. Additionally, EPA reviewed its database for establishing General Metals NSPS based on the Option 2 technology as commentors indicated the proposed standards were not technically achievable.

In response to these comments, EPA reviewed all the information currently available on General Metals facilities employing Option 2 technology. This review demonstrated that process wastewaters at General Metals facilities contain a wide variety of metals in significant concentrations. Commentors stated that single-stage precipitation and solids separation steps may not achieve sufficient removals for wastewaters that contain significant concentrations of a wide variety of metals - especially if the metals preferentially precipitate at disparate pH ranges. Consequently, to address concerns raised by commentors, EPA also costed new sources to operate two separate chemical precipitation and solids separation steps in series. Two-stage chemical precipitation and solids separation allows General Metals facilities with multiple metals to control metal discharges to concentrations lower than single-stage chemical precipitation and solids separation over a wider pH range.

Applying this revised costing approach, EPA projects a barrier to entry for General Metals NSPS based on the Option 2 technology because 14 percent of General Metals direct dischargers have after-tax compliance costs between 1 to 3 percent of revenue, 22 percent have after-tax compliance costs between 3 to 5 percent of revenue, and 2 percent have after-tax compliance costs greater than 5 percent of revenue. Consequently, based on the compliance costs of the modified Option 2 technology, EPA rejected Option 2 technology as the basis for NSPS in the General Metals Subcategory. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

EPA also considered transferring NSPS from existing Metal Finishing effluent guidelines (40 CFR 433.16) to the General Metals Subcategory. EPA reviewed existing General Metals direct dischargers and found that all are currently either covered by or have permits based on the Metal Finishing limitations at 40 CFR 433. EPA has no basis to conclude that new General Metals facilities would have less stringent requirements than existing facilities, particularly since, in the absence of promulgated NSPS, it is likely that permit writers would consult the Part 433 requirements to establish BPJ limits. In addition, those new facilities which meet the applicability criteria for Part 433 will be subject to the NSPS for that category. Therefore, transferring standards from these existing Metal Finishing effluent limitations guidelines would likely result in no additional pollutant load reductions.

Therefore, based on the lack of additional pollutant removals that are estimated, EPA is not promulgating NSPS for the General Metals Subcategory. EPA is not revising or establishing NSPS for any facilities in this subcategory. Direct dischargers in the General Metals Subcategory will remain regulated by permit limits and Part 433, as applicable.

9.2.5 Pretreatment Standards for Existing Sources (PSES)

As discussed in the June 2002 NODA (67 FR 38798), EPA also considered a number of alternative options whose economic impacts would be less costly than Option 2 technology. These options potentially have compliance costs more closely aligned with toxic pollutant reductions. EPA considered the following alternative options for the final rule:

- Option A: No change in current regulation.

- Option B: Option 2 with a higher low-flow exclusion.

- Option C: Upgrading facilities currently covered by Part 413 to meet the PSES of Part 433 ("413 to 433 Upgrade Option" described below).

- Option D: Upgrading all facilities covered by Part 413 and those facilities covered by "local limits only" that discharge greater than a specified wastewater flow (e.g., 1, 3, or 6.25 million gallons per year (MGY)) of process wastewater to meet the PSES of Part 433 ("Local Limits to 433 Upgrade Option" described below). Note that facilities regulated by "local limits only" are also regulated by the General Pretreatment Standards (40 CFR 403).

413 to 433 Upgrade Option

The 413 to 433 Upgrade Option would require those facilities currently required to meet the standards of the Electroplating effluent limitations guidelines (40 CFR 413) to meet the limitations and standards of the Metal Finishing effluent guidelines (40 CFR 433). Currently, the only facilities that are still completely covered by the Electroplating effluent guidelines are

indirect dischargers that were in existence prior to 1982 and have not significantly upgraded their operations. Therefore, this alternative option applies to only a subset of indirect dischargers within the proposed General Metals, Metal Finishing Job Shops, Printed Wiring Board, and Non-Chromium Anodizing Subcategories.

The technology components that compose the basis for the 413 to 433 Upgrade Option are equivalent to those described for Option 1. Differences in the level of performance (i.e., effluent limitations) between the 413 to 433 Upgrade Option and Option 1 derive from improvements in operation and control of process operations and pollutant control technology since the early 1980s when the Electroplating effluent guidelines were developed.

Local Limits to 433 Upgrade Option

This option would upgrade all facilities covered by Part 413 and those facilities covered by "local limits only" that discharge greater than a specified wastewater flow (e.g., 1, 3, or 6.25 million gallons per year) of process wastewater to meet the PSES of Part 433. Accordingly, this technology option applies to only a subset of indirect dischargers within the proposed General Metals Subcategory. A separate but similar alternative option (see Section 9.2.1) applies to direct dischargers.

The technology components that compose the basis for the Local Limits to 433 Upgrade Option are equivalent to those described for Option 1. Differences in treatment performance (i.e., effluent limitations) between the Local Limits to 433 Upgrade Option and Option 1 derive from improvements in operation and control of pollutant control technology implemented since the early 1980s when the Electroplating effluent guidelines were developed.

Option Selection Discussion

EPA proposed to establish PSES for existing indirect dischargers in the General Metals Subcategory based on the Option 2 technology (i.e., the same technology basis that EPA considered for BPT/BCT/BAT for this subcategory) with a "low-flow" exclusion of 1 MGY to reduce economic impacts on small businesses and administrative burden for control authorities. Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and in Sections 11.0 and 12.0, EPA rejected promulgating PSES for existing indirect dischargers in the General Metals Subcategory based on the Option 2 technology for the following reasons: (1) many General Metals indirect dischargers are currently regulated by existing effluent guidelines (Parts 413 or 433 or both, as applicable); (2) EPA estimates that compliance with PSES based on the Option 2 technology will result in the closure of approximately 4 percent of the existing indirect dischargers in this subcategory; and (3) EPA determined that the incremental toxic pollutant reductions are very expensive per pound removed (the cost-effectiveness value (in 1981$) for Option 2 for indirect dischargers in the General Metals Subcategory is $432/PE).

This suggests to EPA that the identified technology is not truly "available" to this industry because it would remove a relatively small number of additional toxic pounds at a cost significantly greater than that EPA has typically determined is appropriate for other industries. Therefore, EPA has determined that Option 2 technology is not the best available technology economically achievable for existing indirect dischargers in the General Metals Subcategory, and is not establishing PSES for this subcategory based on the Option 2 technology.

Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and in Sections 11.0 and 12.0, EPA has revised its methodology for estimating compliance costs and pollutant loadings for Option 2, higher low-flow exclusions (Option B), and the "upgrade" options (Options C and D) previously described. Using information from this revised analysis, EPA concludes that all of these alternative options (Options B, C, and D) are either not available or not economically achievable. EPA rejected Options B, C, and D because: (1) more than 10 percent of existing indirect dischargers not covered by Part 433 close at the upgrade option; or (2) toxic removals of the upgrade options are quite expensive (cost-effectiveness values (in 1981$) in excess of $420/PE), suggesting that these options are not truly available technologies for this industry segment.

EPA consequently determined that none of the treatment options represented best available technology economically achievable. Therefore, EPA is not revising or establishing PSES for existing indirect dischargers in the General Metals Subcategory (Option A). Wastewater discharges to POTWs from facilities in this subcategory will remain regulated by local limits, General Pretreatment Standards (Part 403), and Parts 413 and/or 433, as applicable. EPA also notes that facilities regulated by Parts 413 and/or 433 PSES must comply with Part 433 PSNS if the changes to their facilities are determined to make them new sources.

9.2.6 Pretreatment Standards for New Sources (PSNS)

In 2001, EPA proposed pretreatment standards for new sources based on the Option 4 technology basis. Option 4 technology is similar to Option 2 (including Option 2 flow control and pollution prevention) but includes oils removal using ultrafiltration and solids separation by a microfilter (instead of a clarifier). As explained in Section 9.2.4, EPA concluded that its database is insufficient to support a determination that the Option 4 standards are technically achievable. As a result, for the final rule, EPA considered establishing PSNS in the General Metals Subcategory based on the Option 2 technology (i.e., the same technology basis that was considered for BPT/BCT/BAT for this subcategory) along with the same "low-flow" exemption of 1 MGY considered for existing sources.

For the final rule, EPA evaluated setting General Metals PSNS based on the Option 2 technology and assessed the financial burden to new General Metals indirect dischargers. Specifically, EPA's 'barrier-to-entry' analysis identified whether General Metals PSNS based on the Option 2 technology would pose sufficient financial burden on new General Metals facilities to constitute a material barrier to entry into the MP&M Point Source Category.

EPA projects a barrier to entry for General Metals PSNS based on the Option 2 technology because 14 percent of General Metals indirect dischargers have after-tax compliance costs between 1 to 3 percent of revenue and 20 percent have after-tax compliance costs between 3 to 5 percent of revenue. Consequently, EPA rejected Option 2 technology as the basis for PSNS in the General Metals Subcategory. EPA has selected "no further regulation," and is not revising PSNS for new General Metals indirect dischargers. Wastewater discharges to POTWs from facilities in this subcategory will remain regulated by local limits, General Pretreatment Standards (Part 403), and Part 433, as applicable. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

9.3   Metal Finishing Job Shops Subcategory

EPA is not revising any limitations or standards for facilities that would have been subject to this subcategory. Such facilities will continue to be regulated by the General Pretreatment Standards (Part 403), local limits, permit limits, and Parts 413 and/or 433, as applicable.

9.3.1   BPT, BCT, and BAT

EPA evaluated several technology options for direct dischargers for the Metal Finishing Job Shops (MFJS) Subcategory. Facilities in this subcategory perform unit operations that primarily generate metal-bearing wastewater, but may also generate some oily wastewater. EPA evaluated Options 1, 2, 2S, 3, and 4, which are described in detail in Section 9.2.1. As discussed in Section 9.2.1, EPA dropped Options 1, 2S, 3, and 4 from further consideration. Therefore, for the final rule, EPA considered only Option 2 as the basis for limitations for the MFJS Subcategory. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 2.

EPA proposed to establish BPT/BCT/BAT for existing direct dischargers in the MFJS Subcategory based on the Option 2 technology (see Section 9.2.1 for a description of Option 2). EPA evaluated the cost of effluent reductions, pollutant reductions, and the economic achievability of compliance with BPT/BCT/BAT limitations based on the Option 2 technology. Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and in Sections 11.0 and 12.0, EPA determined that the compliance costs of the Option 2 technology are not economically achievable.

EPA estimates that compliance with BPT/BCT/BAT limitations based on the Option 2 technology will result in the closure of 50 percent of the existing direct dischargers in this subcategory (12 of 24 existing MFJS direct dischargers). Consequently, EPA concludes that, for existing direct dischargers in the MFJS Subcategory, Option 2 is not the best practicable control technology, best conventional pollutant control technology, or best available technology economically achievable. EPA has decided not to establish new BPT, BCT, or BAT limitations

for existing MFJS direct dischargers based on the Option 2 technology; these discharges will remain subject to Part 433.

9.3.2   NSPS

EPA proposed to establish NSPS for new direct dischargers in the MFJS Subcategory based on the Option 4 technology. Option 4 technology is similar to Option 2 (including Option 2 flow control and pollution prevention) but includes oils removal using ultrafiltration and solids separation by a microfilter (instead of a clarifier). As explained in Section 9.2.4, EPA concluded that its database is insufficient to support a determination that the Option 4 standards are technically achievable. Consequently, EPA rejected Option 4 technology as the basis for NSPS in the MFJS Subcategory.

For the final rule, EPA evaluated setting MFJS NSPS based on the Option 2 technology and assessed the financial burden to new MFJS direct dischargers. Specifically, EPA's 'barrier-to-entry' analysis identified whether MFJS NSPS based on the Option 2 technology would pose sufficient financial burden so as to constitute a material barrier to entry into the MP&M point source category. Additionally, EPA reviewed its database for establishing MFJS NSPS based on the Option 2 technology as commentors indicated the proposed standards were not technically achievable.

In response to these comments, EPA reviewed all the information currently available on MFJS facilities using the Option 2 technology basis. This review demonstrated that process wastewaters at MFJS facilities contain a wide variety of metals in significant concentrations. Commentors stated that single-stage precipitation and solids separation may not achieve sufficient removals for wastewaters that contain significant concentrations of a wide variety of metals, especially if the metals preferentially precipitate at disparate pH ranges. Consequently, to address concerns raised by commentors, EPA also costed new sources to operate two separate chemical precipitation and solids separation steps in series. Two-stage chemical precipitation and solids separation allows MFJS facilities with multiple metals to control metal discharges to concentrations lower than single-stage chemical precipitation and solids separation over a wider pH range.

Applying this revised costing approach, EPA projects a barrier to entry for MFJS NSPS based on the Option 2 technology because all MFJS direct dischargers have new source compliance costs that are greater than 5 percent of revenue. Consequently, EPA rejected Option 2 technology as the basis for NSPS in the MFJS Subcategory, and is not revising NSPS for new MFJS direct dischargers. Wastewater discharges from these facilities in this subcategory will remain regulated by local limits and Part 433 NSPS as applicable. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

9.3.3　　　PSES

EPA evaluated several technology options for indirect dischargers for the MFJS Subcategory, whose unit operations primarily generate metal-bearing wastewater, but may also generate some oily wastewater. These include the same option as evaluated for BAT (i.e., Option 2), as well as several alternative options discussed below. EPA did not further evaluate Options 1, 2S, 3, and 4 for the final rule for the same reasons as explained for BPT above. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 2 and the alternative options considered for the final rule.

EPA proposed to establish PSES for existing indirect dischargers in the MFJS Subcategory based on the Option 2 technology. Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, EPA determined that the costs of Option 2 are not economically achievable for existing indirect dischargers in the MFJS Subcategory. EPA estimates that compliance with PSES based on the Option 2 technology will result in the closure of 46 percent of the existing indirect dischargers in this subcategory (589 of 1,270 existing MFJS indirect dischargers), which EPA considers to be too high. EPA has determined that Option 2 technology is not the best available technology economically achievable for existing indirect dischargers in the MFJS Subcategory. Therefore, EPA is not establishing PSES for this subcategory based on the Option 2 technology.

As discussed in the January 2001 proposal (66 FR 551) and June 2002 NODA (67 FR 38801), EPA also considered a number of alternative options whose economic impacts would be less costly than Option 2 technology. These options potentially have compliance costs more closely aligned with toxic pollutant reductions. EPA considered the following alternative options for the final rule:

- Option A: No change in current regulation;

- Option B: Option 2 with a higher low-flow exclusion;

- Option C: Upgrading facilities currently covered by Part 413 to meet the PSES of Part 433 ("413 to 433 Upgrade Option" described in Section 9.2.5); and

- Option D: Pollution prevention option (see 66 FR 551).

All facilities in the MFJS Subcategory are currently subject to Part 413, Part 433 or both.

As discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, based on comments, EPA has revised its methodology for estimating compliance costs and pollutant loadings for Option 2, low-flow exclusions (Option B), and the "upgrade" option (Option C) previously described. Using information from this revised analysis, EPA concludes

that neither of these alternative options (Options B or C) are economically achievable. EPA rejected Options B and C because more than 10 percent of existing indirect dischargers not covered by Part 433 close at the upgrade option.

EPA also solicited comment in the January 2001 proposal on a pollution prevention alternative for indirect dischargers in this subcategory (Option D). Commentors supported Option D and stated that the pollution prevention practices identified by EPA in the January 2001 proposal represent environmentally sound practices for the metal finishing industry. The commentors also stated that Option D should, however, be implemented on a voluntary basis similar to the National Metal Finishing Strategic Goals Program (see 66 FR 511). Control authorities also commented that Option D may increase their administrative burden because of additional review of facility operations and compliance with the approved pollution prevention plan, and enforcement of Option D may be more difficult than other options considered. EPA is not promulgating Option D for facilities in the MFJS Subcategory for the final rule due to the increased administrative burden on pretreatment control authorities and potential problems enforcing Option D. Section 8.0 describes many of the pollution prevention practices that were considered for Option D. These pollution prevention practices may be useful in helping facilities lower operating costs, improve environmental performance, and foster other important benefits.

EPA is not establishing PSES for existing indirect dischargers in the MFJS Subcategory. Wastewater discharges to POTWs from facilities in this subcategory will remain regulated by General Pretreatment Standards (Part 403), and Parts 413 and/or 433, as applicable. EPA also notes that facilities regulated by Parts 413 and/or 433 PSES must comply with Part 433 PSNS if the changes to their facilities are determined to make them new sources.

9.3.4   PSNS

EPA proposed to establish PSNS for indirect dischargers in the MFJS Subcategory based on the Option 4 technology. Option 4 technology is similar to Option 2 (including Option 2 flow control and pollution prevention) but includes oils removal using ultrafiltration and solids separation by a microfilter (instead of a clarifier). As explained in Section 9.2.4, EPA concluded its database is insufficient to support a determination that the Option 4 standards are technically achievable. Consequently, EPA rejected Option 4 technology as the basis for PSNS in the MFJS Subcategory.

For the final rule, EPA evaluated setting MFJS PSNS based on the Option 2 technology and assessed the financial burden to new MFJS indirect dischargers. Specifically, EPA's 'barrier-to-entry' analysis identified whether MFJS PSNS based on the Option 2 technology would pose sufficient financial burden on new MFJS facilities to constitute a material barrier to entry into the MP&M Point Source Category.

EPA projects a barrier to entry for MFJS PSNS based on the Option 2 technology because 8 percent of MFJS indirect dischargers have after-tax compliance costs between 1 to 3

percent of revenue, 5 percent have after-tax compliance costs between 3 to 5 percent of revenue, and 6 percent have after-tax compliance costs greater than 5 percent of revenue. Consequently, EPA rejected Option 2 technology as the basis for PSNS in the MFJS Subcategory, and is not revising PSNS for new MFJS indirect dischargers. Wastewater discharges to POTWs from facilities in this subcategory will remain regulated by local limits, General Pretreatment Standards (Part 403), and Part 433, as applicable. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

9.4 Non-Chromium Anodizing Subcategory

EPA is not revising limitations or standards for any facilities that would have been subject to this subcategory. Such facilities will continue to be regulated by the General Pretreatment Standards (Part 403), local limits, permit limits, and Parts 413 and/or 433, as applicable.

9.4.1 BPT, BCT, and BAT

As previously discussed, after publication of the June 2002 NODA, EPA conducted another review of all Non-Chromium Anodizing (NCA) facilities in the MP&M survey database to determine the destination of discharged wastewater (i.e., either directly to surface waters or indirectly to POTWs or both) and the applicability of the final rule to discharged wastewaters. As a result of this review, EPA did not identify any NCA direct discharging facilities or NCA facilities that do not discharge wastewater (i.e., zero discharge or contract haulers) or do not use process water (dry facilities) in its rulemaking record. All of the NCA facilities in EPA's database are indirect dischargers. Therefore, EPA cannot evaluate treatment systems at direct dischargers. As a result, EPA transferred cost and pollutant loading data from the best performing indirect facilities in order to evaluate direct discharging limitations in this subcategory.

EPA evaluated several technology options for direct dischargers for the NCA Subcategory, whose unit operations primarily generate metal-bearing wastewater, but may also generate some oily wastewater. These include Options 1, 2, 2S, 3, and 4, which are described in detail in Section 9.2.1. As discussed in Section 9.2.1, EPA dropped Options 1, 2S, 3, and 4 from further consideration. Therefore, for the final rule, EPA considered only Option 2 as the basis for limitations for the NCA Subcategory. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 2.

In 2001, EPA proposed to establish BPT/BCT/BAT limitations for direct dischargers in the NCA Subcategory based on the Option 2 technology. EPA evaluated the cost of effluent reductions, quantity of pollutant reductions, and the economic achievability of compliance with BPT/BCT/BAT limitations based on the Option 2 technology. Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, the costs of the Option 2 technology were

disproportionate to the projected toxic pollutants reductions (cost-effectiveness values (in 1981$) in excess of $1,925/PE).

EPA decided not to establish BPT/BAT limitations based on the Option 2 technology for the NCA Subcategory for following reasons: (1) EPA identified no NCA direct dischargers, and (2) the costs of Option 2 are disproportionate to the estimated toxic pollutant reductions (i.e., $1,925/PE). EPA concludes that for existing direct dischargers in the NCA Subcategory, Option 2 is not the best practicable control technology, best conventional pollutant control technology, or best available technology economically achievable. EPA has decided not to establish new BPT, BCT, or BAT limitations for existing NCA direct dischargers based on the Option 2 technology. Although, EPA identified no NCA direct dischargers through its survey efforts, if such facilities do exist, they would be subject to Part 433.

9.4.2 NSPS

EPA proposed to establish NSPS for direct dischargers in the NCA Subcategory based on the Option 2 technology. For the final rule, EPA evaluated setting NCA NSPS based on the Option 2 technology and assessed the financial burden to new NCA direct dischargers. Specifically, EPA's 'barrier-to-entry' analysis identified whether NCA NSPS based on the Option 2 technology would pose sufficient financial burden on new NCA facilities to constitute a material barrier to entry into the MP&M Point Source Category.

EPA projects a barrier to entry for NCA NSPS based on the Option 2 technology because approximately 26 percent of NCA direct dischargers have new source compliance costs that are between 3 percent and 5 percent of revenue. Consequently, EPA rejected Option 2 technology as the basis for NSPS in the NCA Subcategory. EPA has selected "no further regulation" for new NCA direct dischargers and is not revising NSPS for new NCA direct dischargers, which will remain subject to Part 433. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

9.4.3 PSES and PSNS

EPA proposed "no further regulation" for existing and new indirect dischargers in the NCA Subcategory. EPA based this decision on the economic impacts to indirect dischargers associated with Option 2 and the small quantity of toxic pollutants discharged by facilities in this subcategory, even after a economically achievable flow cutoff is applied (see 66 FR 467). For the reasons set out in the 2001 proposal, EPA has decided not to establish new regulations and is not establishing PSES or PSNS in the NCA Subcategory. These facilities remain subject to Parts 413 or 433, or both, as applicable. EPA also notes that facilities regulated by Parts 413 and/or 433 PSES must comply with Part 433 PSNS if the changes to their facilities are determined to make them new sources.

9.5 <u>Printed Wiring Board Subcategory</u>

EPA is not revising any limitations or standards for facilities that would have been subject to this subcategory. Such facilities will continue to be regulated by the General Pretreatment Standards (Part 403), local limits, permit limits, and Parts 413 and/or 433, as applicable.

9.5.1 BPT, BCT, and BAT

EPA evaluated several technology options for direct dischargers for the Printed Wiring Board (PWB) Subcategory, whose unit operations primarily generate metal-bearing wastewater, but may also generate some oily wastewater. These include Options 1, 2, 2S, 3, and 4, which are described in detail in Section 9.2.1. As discussed in Section 9.2.1, EPA dropped Options 1, 2S, 3, and 4 from further consideration. Therefore, for the final rule, EPA considered only Option 2 as the basis for limitations for the PWB Subcategory. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 2.

EPA proposed to establish BPT/BCT/BAT for direct dischargers in the PWB Subcategory based on the Option 2 technology (see Section 9.2.1 for a description of Option 2). EPA evaluated the cost of effluent reductions, pollutant reductions, and the economic achievability of compliance with BPT/BCT/BAT limitations based on the Option 2 technology.

Based on MP&M survey information, EPA estimates that compliance with BPT/BCT/BAT limitations based on the Option 2 technology results in no closures of the existing eight direct dischargers in the PWB Subcategory. However, EPA decided not to establish BPT/BAT limitations based on the Option 2 technology for the PWB Subcategory for the following reasons: (1) EPA identified only eight existing PWB direct dischargers and all of these PWB direct dischargers are currently regulated by existing effluent guidelines (Part 433), and (2) the costs of Option 2 are disproportionate to the estimated toxic pollutant reductions. EPA estimates compliance costs of $0.3 million (2001$ dollars) with only 186 toxic pound-equivalents (PE) being removed. This equates to a cost-effectiveness value (in 1981$) of approximately $900/PE. EPA concludes that, for existing direct dischargers in the PWB Subcategory, Option 2 is not the best practicable control technology, best conventional pollutant control technology, or best available technology economically achievable. EPA has decided not to establish new BPT, BCT, or BAT limitations for existing PWB direct dischargers based on the Option 2 technology; these discharges will remain subject to Part 433.

9.5.2 NSPS

EPA proposed to establish NSPS for new direct dischargers in the PWB Subcategory based on the Option 4 technology. Option 4 technology is similar to Option 2 (including Option 2 flow control and pollution prevention) but includes oils removal using ultrafiltration and solids separation by a microfilter (instead of a clarifier). As explained in Section 9.2.4, EPA concluded that its database is insufficient to support a determination that the

Option 4 standards are technically achievable. Consequently, EPA rejected Option 4 technology as the basis for NSPS in the PWB Subcategory.

For the final rule, EPA evaluated setting PWB NSPS based on the Option 2 technology. EPA reviewed its database for establishing PWB NSPS based on the Option 2 technology as commentors indicated the proposed standards were not technically achievable. In response to these comments, EPA reviewed all the information currently available on PWB facilities using the Option 2 technology basis. EPA now concludes that the PWB's Option 2 database can only be used to establish limitations for copper, nickel, and tin. In order to assess the difference between current NSPS requirements (from Part 433) for PWB facilities and those under consideration in the final rule, EPA estimated the incremental quantities of copper, nickel, and tin that would be reduced if a new PWB facility were required to meet NSPS based on the Option 2 technology rather than NSPS based on Part 433. EPA analysis shows minimal amounts of pollutant reductions based on more stringent requirements on copper, nickel, and tin.

Consequently, EPA rejected Option 2 technology as the basis for NSPS in the PWB Subcategory based on the small incremental quantity of toxic pollutants that would be reduced in relation to existing requirements. EPA is not establishing NSPS or revising existing NSPS for new PWB direct dischargers. Wastewater discharges from these facilities in this subcategory will remain regulated by permit limits and Part 433 as applicable. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

9.5.3 PSES

EPA evaluated several technology options for indirect dischargers for the PWB Subcategory, whose unit operations primarily generate metal-bearing wastewater, but may also generate some oily wastewater. These include the same option as evaluated for BAT (i.e., Option 2 as described in Section 9.2.1), as well as several alternative options described below. EPA did not further evaluate Options 1, 2S, 3, and 4 for the final rule for the same reasons as explained for BPT above. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 2 and the alternative options considered for the final rule.

EPA proposed to establish PSES for existing indirect dischargers in the PWB Subcategory based on the Option 2 technology. Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, EPA rejected promulgating PSES for existing indirect dischargers in the PWB Subcategory based on the Option 2 technology for the following reasons: (1) all PWB indirect dischargers are currently regulated by existing effluent guidelines (Parts 413 or 433 or both, as applicable); (2) EPA estimates that compliance with PSES based on the Option 2 technology will result in the closure of 6.5 percent of the existing indirect dischargers in this subcategory (55 of 840 existing PWB indirect dischargers); and (3) EPA determined that the toxic pollutant reductions are very expensive per pound removed (the cost-effectiveness value (in 1981$) is

$455/PE). EPA has determined that Option 2 technology is not the best available technology economically achievable for existing indirect dischargers in the PWB Subcategory, and therefore is not establishing PWB PSES based on the Option 2 technology.

As discussed in the June 2002 NODA (see 67 FR 38802), EPA also considered a number of alternative options whose economic impacts would be less costly than Option 2 technology. These options potentially have compliance costs more closely aligned with toxic pollutant reductions. EPA considered the following alternative options for the final rule:

- Option A: No change in current regulation;

- Option B: Option 2 with a higher low-flow exclusion; and

- Option C: Upgrading facilities currently covered by Part 413 to the PSES of Part 433 ("413 to 433 Upgrade Option").

EPA notes that all facilities in the PWB Subcategory are currently subject to Part 413, Part 433, or both.

As discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, based on comments, EPA has revised its methodology for estimating compliance costs and pollutant loadings for Option 2, higher low-flow exclusions (Option B), and the "upgrade" option (Options C) previously described. Using information from this revised analysis, EPA rejected Options B and C because: (1) more than 10 percent of existing indirect dischargers not covered by Part 433 close at the upgrade option; or (2) the incremental compliance costs of the upgrade options were too great in terms of toxic removals (cost-effectiveness values (in 1981$) in excess of $833/PE). Therefore, EPA is not revising PSES for existing indirect dischargers in the PWB Subcategory. Wastewater discharges to POTWs from facilities in this subcategory will remain regulated by General Pretreatment Standards (Part 403) and Parts 413 and/or 433, as applicable. EPA also notes that facilities regulated by Parts 413 and/or 433 PSES must comply with Part 433 PSNS if the changes to their facilities are determined to make them new sources.

9.5.4 PSNS

EPA proposed to establish PSNS for indirect dischargers in the PWB Subcategory based on the Option 4 technology. Option 4 technology is similar to Option 2 (including Option 2 flow control and pollution prevention) but includes oils removal using ultrafiltration and solids separation by a microfilter (instead of a clarifier). As explained in Section 9.2.4, EPA concluded that its database is insufficient to support a determination that the Option 4 standards are technically achievable. Consequently, EPA rejected Option 4 technology as the basis for PSNS in the PWB Subcategory.

For the final rule, EPA evaluated setting PWB PSNS based on the Option 2 technology and assessed the financial burden to new PWB indirect dischargers. Specifically,

EPA's 'barrier-to-entry' analysis identified whether PWB PSNS based on the Option 2 technology would pose sufficient financial burden on new PWB facilities to constitute a material barrier to entry into the MP&M Point Source Category.

EPA projects a barrier to entry for PWB PSNS based on the Option 2 technology because 3 percent of PWB indirect dischargers have after-tax compliance costs between 1 to 3 percent of revenue and 4 percent have after-tax compliance costs greater than 5 percent of revenue. Consequently, EPA rejected Option 2 technology as the basis for PSNS in the PWB Subcategory. EPA has selected "no further regulation" for new PWB indirect dischargers and is not revising PSNS for new PWB indirect dischargers. Wastewater discharges to POTWs from facilities in this subcategory will remain regulated by local limits, General Pretreatment Standards (Part 403), and Part 433, as applicable. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

9.6 Steel Forming and Finishing Subcategory

EPA is not revising limitations or standards for any facilities that would have been subject to this subcategory. Such facilities will continue to be regulated by the General Pretreatment Standards (Part 403), local limits, permit limits, and Iron and Steel effluent limitations guidelines (Part 420), as applicable.

9.6.1 BPT, BCT, and BAT

EPA evaluated several technology options for direct dischargers for the Steel Forming and Finishing (SFF) Subcategory, whose unit operations primarily generate metal-bearing wastewater, but may also generate some oily wastewater. These include Options 1, 2, 2S, 3, and 4, which are described in detail in Section 9.2.1. As discussed Section 9.2.1, EPA dropped Options 1, 2S, 3, and 4 from further consideration. Therefore, for the final rule, EPA considered only Option 2 as the basis for limitations for the SFF Subcategory. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 2.

EPA proposed to establish BPT/BCT/BAT for existing direct dischargers in the SFF Subcategory based on the Option 2 technology (see Section 9.2.1 for a description of Option 2). For the final rule, EPA evaluated the cost of effluent reductions, pollutant reductions, and the economic achievability of compliance with BPT/BCT/BAT limitations based on the Option 2 technology. Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, EPA determined that the compliance costs of Option 2 are not economically achievable. EPA estimates that compliance with BPT/BCT/BAT limitations based on the Option 2 technology will result in the closure of 17 percent of the existing direct dischargers in this subcategory (7 of 41 existing SFF direct dischargers). EPA concludes that, for existing direct dischargers in the SFF Subcategory, Option 2 is not the best practicable control technology, best conventional pollutant control technology, or best available technology economically achievable, and therefore, EPA is not

establishing new BPT, BCT, or BAT limitations for existing SFF direct dischargers based on the Option 2 technology. These facilities will remain subject to Part 420.

9.6.2   NSPS

EPA proposed to establish NSPS for new direct dischargers in the SFF Subcategory based on the Option 4 technology. Option 4 technology is similar to Option 2 (including Option 2 flow control and pollution prevention) but includes oils removal using ultrafiltration and solids separation by a microfilter (instead of a clarifier). As explained in Section 9.2.4, EPA concluded that its database is insufficient to support a determination that the Option 4 standards are technically achievable. Consequently, EPA rejected Option 4 technology as the basis for NSPS in the SFF Subcategory. EPA has selected "no further regulation" for new SFF direct dischargers and is not revising NSPS for new SFF direct dischargers, which will remain subject to Part 420.

9.6.3   PSES

EPA evaluated several technology options for indirect dischargers for the Steel Forming and Finishing Subcategory, whose unit operations primarily generate metal-bearing wastewater, but may also generate some oily wastewater. For the final rule, EPA considered the same option as evaluated for BAT (i.e., Option 2). EPA did not further evaluate Options 1, 2S, 3, and 4 for the final rule for the same reasons as explained for BPT above. See the Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metal Products & Machinery Point Source Category (EPA 821-B-00-005) for the final estimated compliance costs and pollutant loadings for Option 2.

EPA proposed to establish PSES for existing indirect dischargers in the SFF Subcategory based on the Option 2 technology. Based on the revisions and corrections to the EPA Costs & Loadings Model discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, EPA estimates that compliance with PSES based on the Option 2 technology will result in the closure of 9 percent of the existing indirect dischargers in this subcategory (10 of 112 existing SFF indirect dischargers).

EPA has determined that Option 2 technology is not the best available technology economically achievable for existing indirect dischargers in the SFF Subcategory, and therefore EPA is not revising PSES for this subcategory based on the Option 2 technology. Wastewater discharges to POTWs from these facilities will remain regulated by General Pretreatment Standards (Part 403) and Part 420.

9.6.4   PSNS

EPA proposed to establish PSNS for indirect dischargers in the SFF Subcategory based on the Option 4 technology. Option 4 technology is similar to Option 2 (including Option 2 flow control and pollution prevention) but includes oils removal using ultrafiltration and solids

separation by a microfilter (instead of a clarifier). As explained in Section 9.2.4, EPA concluded its database is insufficient to support a determination that the Option 4 standards are technically achievable. Consequently, EPA rejected Option 4 technology as the basis for PSNS in the SFF Subcategory. EPA has selected "no further regulation" for new SFF indirect dischargers and is not revising PSNS for new SFF indirect dischargers; these facilities will remain subject to Part 420.

9.7   Oily Wastes Subcategory

EPA is promulgating limitations and standards for existing and new direct dischargers in the Oily Wastes Subcategory based on the proposed Option 6 technology (see Section 9.7.1). EPA is not promulgating pretreatment standards for existing or new indirect dischargers in this subcategory.

9.7.1   BPT

EPA evaluated several technology options for the direct dischargers in the Oily Wastes Subcategory. Each of these options is discussed below. As discussed in Section 6.0, EPA defines the Oily Wastes Subcategory as those facilities that only discharge wastewater from one or more oily operations (see Table 6-2 and 40 CFR 438.2(f)).

Option 5

Option 5 consists of end-of-pipe chemical emulsion breaking followed by gravity separation using an oil/water separator. EPA performed sampling episodes at several facilities in the Oily Wastes Subcategory that used chemical emulsion breaking followed by gravity flotation and oil skimming. These systems typically achieved a 96-percent removal of oil and grease. Breaking the oil/water emulsion requires adding treatment chemicals such as acid, alum, and/or polymers to change the emulsified oils or cutting fluids from hydrophilic colloids to aggregate hydrophobic particles. The aggregated oil particles, with a density less than water, can be removed by gravity flotation in a coalescing plate oil/water separator. Option 5 also includes contract hauling of organic solvent-bearing wastewaters instead of discharge.

Option 6

Option 6 consists of the technologies in Option 5 plus the following in-process flow control and pollution prevention technologies, which allow for recovery and reuse of materials along with water conservation:

- Two-stage countercurrent cascade rinsing for all flowing rinses;

- Centrifugation and recycling of painting water curtains; and

- Centrifugation, pasteurization, and recycling of water-soluble machining coolants.

Option 7

Option 7 consists of end-of-pipe ultrafiltration, as well as contract hauling of organic solvent-bearing wastewater instead of discharge. Sampling episode data determined that, on average, ultrafilters will remove greater than 99 percent of all oil and grease in the influent stream.

Option 8

Option 8 consists of the Option 7 technology (ultrafiltration) plus the pollution prevention and water conservation alternatives described in Option 6.

Option Selection

As discussed in the 2001 proposal (66 FR 451), EPA dropped Options 5 and 7 from further consideration because Options 6 and 8, respectively, cost less and provided greater pollutant removals. Subsequent to proposal, EPA also dropped Option 8 from further consideration for the final rule because of its increased cost and lack of significant additional pollutant removals beyond Option 6. Therefore, for the final rule, EPA considered only Option 6 as the basis for limitations for the Oily Wastes Subcategory. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 6.

EPA is establishing BPT pH limitations and daily maximum limitations for two pollutants, oil and grease as hexane extractable material (oil and grease (as HEM)) and total suspended solids (TSS), for direct dischargers in the Oily Wastes Subcategory based on the proposed technology option (Option 6). Option 6 technology includes the following treatment measures: (1) in-process flow control and pollution prevention; and (2) oil/water separation by chemical emulsion breaking and skimming (see above for additional details on the Option 6 technology).

The Agency concluded that the Option 6 treatment technology represents the best practicable control technology currently available and should be the basis for the BPT Oily Wastes limitations for the following reasons. First, this technology is available and readily applicable to all facilities in the Oily Wastes Subcategory. Approximately 42 percent of the direct dischargers in the Oily Wastes Subcategory currently use the Option 6 technology. Second, the cost of compliance with these limitations in relation to the effluent reduction benefits is not wholly disproportionate. None of these wastewater discharges are currently subject to national effluent limitations guidelines and the final rule will control wastewater discharges from a significant number (2,382) of facilities.

EPA estimates that compliance with BPT limitations based on Option 6 technology will result in no closures of the existing direct dischargers in the Oily Wastes Subcategory. Moreover, the adoption of this level of control will significantly reduce the amount of pollutants discharged into the environment by facilities in this subcategory. For facilities in the Oily Wastes Subcategory at Option 6, EPA estimates an annual compliance cost of $13.8 million (pre-tax, 2001$) and 480,325 pounds of conventional pollutants removed from current discharges into the Nation's waters at a cost of $28.73/pound-pollutant removed (2001$). EPA has, therefore, determined that the total cost of effluent reductions as a result of using the Option 6 technology are reasonable in relation to the effluent reduction benefits. (In estimating the pounds of pollutant removed by implementing Option 6 technology for direct dischargers in the Oily Wastes Subcategory, EPA used the sum of oil and grease (as HEM) and TSS pounds removed to avoid any significant double counting of pollutants).

The 2001 proposal also contains detailed discussions explaining why EPA rejected BPT limitations based on other BPT technology options (see 66 FR 457). The information in the record for the final rule provides no basis for EPA to change this conclusion.

In the 2001 proposal, EPA proposed to regulate sulfide in addition to pH, oil and grease (as HEM), and TSS. In the final rule, EPA has not established a sulfide limitation because it may serve as a treatment chemical (see Section 7.0). EPA also proposed three alternatives to control discharges of toxic organics in MP&M process wastewaters: (1) meet a numerical limit for the total sum of a list of specified organic pollutants (similar to the Total Toxic Organic (TTO) parameter used in the Metal Finishing effluent limitations guidelines); (2) meet a numerical limit for total organic carbon (TOC) as an indicator parameter; or (3) develop and certify the implementation of an organic chemicals management plan. EPA evaluated the analytical wastewater and treatment technology data from Oily Wastes facilities and concluded it should not establish a separate indicator parameter or control mechanism for toxic organics. Optimizing the separation of oil and grease from wastewater using the Option 6 technology will similarly optimize the removal of toxic organic pollutants amenable to this treatment technology. Consequently, EPA is effectively controlling toxic organics and other priority and nonconventional pollutant discharges in Oily Wastes Subcategory process wastewaters by regulating oil and grease (as HEM).

In its analyses, EPA estimated that facilities will monitor once per month for oil and grease (as HEM) and TSS. EPA expects that 12 data points for each pollutant per year will yield a meaningful basis for establishing compliance with the promulgated limitations through long-term trends and short-term variability in oil and grease (as HEM) and TSS pollutant discharge loading patterns.

Although EPA is not changing the technology basis from that proposed, EPA is revising all of the proposed Oily Wastes Subcategory BPT limitations. This is a result of a recalculation of the limitations after EPA revised the data sets used to calculate the promulgated limitations to reflect changes including corrections and additional data (see 67 FR 38754).

9.7.2   BCT

In deciding whether to adopt more stringent limitations for BCT than BPT, EPA considered whether there are technologies that achieve greater removals of conventional pollutants than adopted for BPT, and whether those technologies are cost-reasonable under the standards established by the CWA. EPA generally refers to the decision criteria as the "BCT cost test." EPA is promulgating effluent limitations for conventional parameters (e.g., pH, TSS, oil and grease) equivalent to BPT for this subcategory because it identified no technologies that can achieve greater removals of conventional pollutants than the selected BPT technology basis that also pass the BCT cost test. EPA evaluated the addition of ultrafiltration technology to the BPT technology basis as a means to obtain further oil and grease reductions. However, this technology option failed the BCT cost test. For a more detailed description of the BCT cost test and details on EPA's analysis, see Chapter 4 of the EEBA.

9.7.3   BAT

EPA proposed to control toxic and nonconventional pollutants by establishing BAT limitations based on Option 6 technology. As described in Section 9.7.1, EPA has decided not to establish BAT toxic and nonconventional limitations based on the Option 6 technology. While the BPT limitations are cost reasonable, the additional costs associated with compliance with Option 6-generated BAT limitations are not warranted. EPA has determined that these costs, primarily monitoring costs, are not warranted in view of the small quantity of additional effluent reduction (if any) the BAT limitations would produce. As explained above, EPA has determined that the BPT limitation on oil and grease (as HEM) will effectively control toxic and nonconventional discharges in Oily Wastes Subcategory process wastewaters. EPA has not identified any more stringent economically achievable treatment technology option beyond BPT technology (Option 6) that it considered to represent BAT level of control applicable to Oily Wastes Subcategory facilities.

For the reasons explained above, EPA has concluded that it should not establish BAT limitations for specific pollutant parameters for Oily Waste operations. EPA notes that permit writers retain the authority to establish, on a case-by-case basis under Section 301(b)(1)(C) of the CWA, toxic effluent limitations that are necessary to meet state water quality standards.

9.7.4   NSPS

EPA is promulgating NSPS that would control pH and the same conventional pollutants controlled at the BPT and BCT levels. The selected technology basis for NSPS for this subcategory for the final rule is Option 6. This is unchanged from the proposal. EPA projects no barrier to entry for new source direct dischargers associated with Option 6 because: (1) Option 6 technology is currently used at existing direct dischargers (i.e., Option 6 technology is technically available), and (2) there is no barrier to entry for new sources.

EPA evaluated the economic impacts for existing direct dischargers associated with compliance with limitations based on Option 6 and found Option 6 to be economically achievable (no closures projected). EPA expects compliance costs to be lower for new sources as new sources can use Option 6 technology without incurring retrofitting costs (as is required for some existing sources). Additionally, EPA projects no barrier to entry for Oily Wastes NSPS based on the Option 6 technology because approximately 97 percent of Oily Wastes direct dischargers have after-tax compliance costs less than 1 percent of revenue and 3 percent have after-tax compliance costs between 1 to 3 percent of revenue.

In addition, EPA also evaluated and rejected more stringent technology options for Oily Wastes NSPS (i.e., Options 8 and 10). EPA reviewed its database for the Option 8 and 10 technologies and found that the database for Option 8 and 10 technologies is insufficient (i.e., no available data) or the costs are not commensurate with the pollutant removals (see 66 FR 457).

Consequently, EPA selected Option 6 technology as the basis for NSPS in the Oily Wastes Subcategory. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

In addition, EPA also evaluated and rejected more stringent technology options for Oily Wastes NSPS (i.e., Options 8 and 10). EPA reviewed its database for the Option 8 and 10 technologies and found no available data for Option 8 and 10 technologies. Since EPA's database did not contain Option 10 treatability data from Oily Wastes facilities, EPA considered transferring limitations for Option 10 from the Shipbuilding Dry Dock or Railroad Line Maintenance Subcategories. EPA ultimately rejected this approach, however, because influent wastewaters in the Shipbuilding Dry Dock and Railroad Line Maintenance Subcategories are generally less concentrated and contain less pollutants than wastewaters discharged by Oily Wastes facilities.

9.7.5   PSES

EPA evaluated the same technology options for indirect dischargers in the Oily Wastes Subcategory as for direct dischargers in the subcategory. For the final rule, EPA considered the same option as evaluated for BAT (i.e., Option 6). EPA did not further evaluate Options 5, 7, and 8 for the final rule for the same reasons as explained for BPT above. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 6.

EPA proposed to establish PSES for existing indirect dischargers in the Oily Wastes Subcategory based on the Option 6 technology (i.e., the same technology basis that is being promulgated for BPT/BCT/NSPS for this subcategory) with a "low-flow" exclusion of 2 MGY to reduce economic impacts on small businesses and administrative burden for control authorities. Based on the revisions and corrections to the EPA Costs & Loadings Model

discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, and previously discussed, EPA determined that the toxic pollutant reductions are very expensive in dollars per toxic pounds removed. The cost-effectiveness value (in 1981$) for Option 6 for indirect dischargers in the Oily Wastes Subcategory is in excess of $3,500/PE removed. This suggests that the technology is not truly "available." EPA has determined that Option 6 technology with a 2-MGY low-flow cutoff is not the best available technology economically achievable for existing indirect dischargers in the Oily Wastes Subcategory. Therefore, EPA is not establishing PSES for this subcategory based on Option 6 technology with a 2-MGY low-flow cutoff.

As discussed in the June 2002 NODA (67 FR 38804), EPA also considered alternative options for which economic impacts could be less costly than Option 6 technology with a 2-MGY low-flow cutoff. These options potentially have compliance costs more closely aligned with toxic pollutant reductions. EPA considered the following alternative options for the final rule:

- Option A: No regulation; and
- Option B: Option 6 with a higher low-flow exclusion.

As discussed in the NODA, preamble to the final rule, and Sections 11.0 and 12.0, based on comments, EPA has revised its methodology for estimating compliance costs and pollutant loadings for Option 6 with a higher low-flow exclusion (Option B). Using information from this revised analysis, EPA concludes that none of the alternative low-flow exclusions (even as high as 6.25 MGY) represented "available technology" because the costs associated with these alternatives were not commensurate with the projected toxic pollutants reductions. Therefore, EPA is not establishing PSES for existing indirect dischargers in the Oily Wastes Subcategory (Option A). Since EPA did not identify another technology basis that was more cost-effective, EPA is not promulgating PSES for existing indirect dischargers in the Oily Wastes Subcategory. These facilities remain subject to the General Pretreatment Standards (40 CFR 403) and local limits, as applicable.

9.7.6   PSNS

EPA proposed to establish PSNS for indirect dischargers in the Oily Wastes Subcategory based on the Option 6 technology (i.e., the same technology basis that is being promulgated for NSPS for this subcategory) with a "low-flow" exclusion of 2 MGY to reduce economic impacts on small businesses and reduce administrative burden to POTWs.

For the final rule, EPA evaluated setting Oily Wastes PSNS based on Option 6 technology and assessed the financial burden of Oily Wastes PSNS based on Option 6 technology on new Oily Wastes indirect dischargers. Specifically, EPA's 'barrier-to-entry' analysis identified whether Oily Wastes PSNS based on Option 6 technology would pose sufficient financial burden on new Oily Wastes facilities to constitute a material barrier to entry into the MP&M Point Source Category.

EPA projects a barrier to entry for Oily Waste PSNS based on Option 6 technology as approximately because 1 percent of Oily Waste indirect dischargers have after-tax compliance costs between 1 to 3 percent of revenue and 5 percent have after-tax compliance costs between 3 to 5 percent of revenue. Consequently, EPA rejected Option 6 technology as the basis for PSNS in the Oily Wastes Subcategory. EPA has selected "no further regulation" for new Oily Wastes indirect dischargers and is not revising PSNS for new Oily Wastes indirect dischargers. Wastewater discharges to POTWs from facilities in this subcategory will remain regulated by local limits and General Pretreatment Standards (Part 403), as applicable. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

9.8 Railroad Line Maintenance Subcategory

EPA is not establishing limitations or standards for any facilities that would have been subject to this subcategory. Permit writers and control authorities will establish controls using BPJ to regulate wastewater discharges from these facilities.

9.8.1 BPT

At proposal, EPA evaluated four technology options for the Railroad Line Maintenance (RRLM) Subcategory. These included Options 7 and 8, which are described in detail in Section 9.7.1, and Options 9 and 10, described below. In addition, for the final rule, EPA evaluated Option 6 for this subcategory (see Section 9.7.1).

Option 9

Option 9 consists of end-of-pipe chemical emulsion breaking followed by dissolved air flotation (DAF) to remove flocculated oils. This treatment train is demonstrated in both the Shipbuilding Dry Dock and RRLM Subcategories and effectively removes emulsified oils and suspended solids. Option 9 also includes contract hauling of organic solvent-bearing wastewater instead of discharge.

Option 10

Option 10 consists of the end-of-pipe treatment technologies included in Option 9 plus in-process flow control and pollution prevention technologies, which allow for recovery and reuse of materials along with water conservation. The specific Option 10 in-process technologies include:

- Two-stage countercurrent cascade rinsing for all flowing rinses;

- Centrifugation and recycling of painting water curtains; and

- Centrifugation, pasteurization, and recycling of water soluble machining coolants.

Option Selection

For the final rule, EPA evaluated setting BPT limitations for two pollutants, TSS and oil and grease (as HEM), for direct dischargers in the RRLM Subcategory based on a different technology basis from that proposed in 2001. EPA proposed Option 10 technology as the technology basis for BPT. However, as discussed in the NODA, EPA considered promulgating limitations for the final rule based on the Option 6 technology for the RRLM Subcategory (see 67 FR 38804). Option 6 technology includes the following: (1) in-process flow control and pollution prevention; and (2) oil/water separation by chemical emulsion breaking and skimming (see Section 9.7.1 for additional details on the Option 6 technology).

For the RRLM Subcategory, EPA changed the technology basis considered for the final rule based on comments and data submitted by the American Association of Railroads (AAR). This organization is a trade association that currently represents all facilities in this subcategory. As discussed in the NODA (67 FR 38755), for each RRLM direct discharging facility known to them, AAR provided current permit limits, treatment-in-place, and summarized information on each facility's measured monthly average and daily maximum values. AAR also provided a year's worth of long-term monitoring data for each facility (see Section 15.1 of the rulemaking record for the AAR surveys). This data shows that, contrary to EPA's initial findings in the 2001 proposal, most RRLM direct dischargers treat their wastewater by chemical emulsion breaking/oil skimming (Option 6). Based on this updated information, EPA rejected Option 10 as the technology basis for BPT. The 2001 proposal also contains detailed discussions on why EPA rejected BPT limitations based on other BPT technology options (see 66 FR 451). The information in the rulemaking record provides no basis for EPA to change this conclusion.

As previously discussed, after publication of the June 2002 NODA, EPA also conducted another review of all RRLM facilities in the MP&M survey database to determine the destination of discharged wastewater (i.e., either directly to surface waters or indirectly to POTWs or both) and the applicability of the final rule to discharged wastewaters. As a result of this review, EPA determined that its survey database did not accurately represent direct dischargers in this subcategory. Consequently, for the final rule, EPA used the information supplied by AAR as a basis for its analyses and conclusions on direct dischargers in this subcategory.

AAR provided information on 27 facilities. EPA reviewed the information on each of these facilities to ensure they were direct dischargers, discharged wastewaters resulting from operations subject to this final rule, and discharged "process" wastewaters as defined by the final rule. As a result of this review, EPA concluded that 18 of the facilities for which AAR provided information do not directly discharge wastewaters exclusively from oily operations (see Section V.A of the preamble to the final rule). Therefore, EPA's final database consists of data for nine direct discharging RRLM facilities. EPA considered promulgating BPT limitations for

these nine direct discharging RRLM facilities based on the Option 6 technology. The Agency made the following conclusions during its evaluation of Option 6 for this subcategory.

First, this technology is readily applicable to all facilities in the RRLM Subcategory. All direct dischargers in the RRLM Subcategory currently use wastewater treatment equivalent or better than chemical emulsion breaking/oil skimming (Option 6). Second, EPA estimates that compliance with BPT limitations based on Option 6 technology will result in no closures of the existing direct dischargers in the RRLM Subcategory. Moreover, none of the facilities identified by AAR are small businesses as defined by the Small Business Administration (SBA). Third, most of the RRLM facilities identified by AAR have NPDES daily maximum permit limitations for oil and grease (as HEM) and TSS as 15 and 45 mg/L, respectively. Based on AAR survey information, EPA concludes that these oil and grease (as HEM) and TSS daily maximum limits represent the average of the best performances of facilities utilizing Option 6 technology.

EPA evaluated the compliance costs and load reductions associated with establishing BPT daily maximum limitations equivalent to 15 and 45 mg/L for oil and grease (as HEM) and TSS, respectively. EPA concluded that all of the facilities identified by AAR currently meet a daily maximum oil and grease limit of 15 mg/L and most currently monitor once per month. Therefore, EPA estimates no pollutant load reductions and minimal incremental annualized compliance costs for the monitoring associated with a BPT daily maximum limitation equivalent to 15 mg/L for oil and grease (as HEM). For TSS, with the exception of one facility, all RRLM facilities identified by AAR currently meet a daily maximum limit of 45 mg/L. For this one facility, EPA estimates the TSS pollutant loadings reductions associated with a BPT daily maximum limitation equivalent to 45 mg/L to be less than 1 pound of TSS per day. Given the fact that the few facilities in this subcategory are already essentially achieving the limitations under consideration, EPA has determined that additional national regulation is not warranted. As a result of this analysis, EPA concludes that it is more appropriate to address permits limitations for this industry on a case-by-case basis and that additional national regulation of direct discharges in the RRLM Subcategory at this time is unwarranted.

9.8.2 BCT

In deciding whether to adopt more stringent limitations for BCT than BPT, EPA considers whether there are technologies that achieve greater removals of conventional pollutants than adopted for BPT, and whether those technologies are cost-reasonable under the standards established by the CWA. EPA generally refers to the decision criteria as the "BCT cost test." For a more detailed description of the BCT cost test and details of EPA's analysis, see Chapter 4 of the EEBA.

For the reasons discussed above, EPA is not establishing BCT limitations for the RRLM Subcategory.

9.8.3   BAT

As proposed, EPA is not establishing BAT regulations for the RRLM Subcategory. EPA did not propose BAT regulations because the Agency concluded that facilities in this subcategory discharge very few pounds of toxic pollutants. EPA estimates that six facilities discharge 34 PE per year to surface waters, or about 6 PE per year per facility. The Agency based the loadings calculations on EPA sampling data, which found very few priority toxic pollutants at treatable levels in raw wastewater. EPA has received no data or information during the rulemaking that contradicts these conclusions. Therefore, nationally applicable regulations for toxic and nonconventional pollutants are unnecessary at this time and direct dischargers will remain subject to permit limitations for toxic and nonconventional pollutants established on a case-by-case basis using BPJ.

9.8.4   NSPS

EPA proposed setting NSPS based on Option 10 technology for this subcategory. For the final rule, EPA considered setting RRLM NSPS based on Option 10 technology and assessed the financial burden of RRLM NSPS based on Option 10 technology on new RRLM direct dischargers. Specifically, EPA's 'barrier-to-entry' analysis identified whether RRLM NSPS based on Option 10 technology would pose sufficient financial burden as to constitute a material barrier to entry into the MP&M Point Source Category.

EPA projects no barrier to entry for RRLM NSPS based on Option 10 technology because: (1) Option 10 technology is currently used at existing RRLM direct dischargers (i.e., Option 10 technology is technically available), and (2) all RRLM direct dischargers have new source compliance costs that are less than 1 percent of revenue. However, EPA is not promulgating RRLM NSPS based on the Option 10 technology because EPA concludes that it is more appropriate to address limitations for this industry on a case-by-case basis and that national regulation of direct discharges in the RRLM Subcategory at this time is unwarranted. See Section 11.0 for a description of how these new source compliance costs were developed and Chapter 9 of the EEBA for a description of the framework EPA used for the barrier-to-entry analysis and general discussion of the results.

9.8.5   PSES and PSNS

EPA proposed not to establish pretreatment standards for existing and new indirect dischargers in the RRLM Subcategory based on the small quantity of toxic pollutants discharged to the environment (after POTW treatment) by facilities in this subcategory (i.e., approximately 2 PE removed annually per facility (see 66 FR 470-471)). For the same reasons set out in the 2001 proposal, EPA is not promulgating pretreatment standards for existing or new indirect dischargers in this subcategory. These facilities remain subject to the General Pretreatment Standards (40 CFR 403) and local limits.

9.9 **Shipbuilding Dry Dock Subcategory**

EPA is not establishing limitations or standards for any facilities that would have been subject to this subcategory. Permit writers and control authorities will establish controls using BPJ to regulate wastewater discharges from these facilities.

9.9.1 **BPT/BCT/BAT/NSPS**

EPA evaluated four technology options for the Shipbuilding Dry Dock (SDD) Subcategory. These include Options 7 and 8, which are described in detail in Section 9.7.1, and Options 9 and 10, which are described in detail in Section 9.8.1.

As discussed in the 2001 proposal (66 FR 451), EPA dropped Options 7 and 9 from further consideration because Options 8 and 10, respectively, cost less and provided greater pollutant removals. EPA also evaluated and rejected a more stringent technology option for SDD NSPS (i.e., Option 8). EPA reviewed its database for the Option 8 technology and found that no available data or possibility of data transfer from the other oily subcategories are available because ultrafiltration does not consistently show a better removal than Option 10 to support a determination that NSPS based on Option 8 standards are technically achievable. EPA concluded that Option 8 does not represent the best practicable control technology. Therefore, for the final rule, EPA considered only Option 10 as the basis for limitations for the SDD Subcategory. See Sections 11.0 and 12.0 for the final estimated compliance costs and pollutant loadings for Option 10.

At the time of the 2001 proposal, EPA identified six direct discharging SDD facilities with multiple discharges. Based on the information in the database at that time, discharges from these facilities contained minimal concentrations of toxic organic and metals pollutants (<9 PE/facility), but substantial quantities of conventional pollutants, particularly oil and grease. Consequently, EPA proposed to establish BPT limitations and NSPS for only two pollutants, TSS and oil and grease (as HEM), for direct dischargers in the SDD Subcategory based on Option 10 technology. This technology includes the following: (1) in-process flow control and pollution prevention, and (2) oil/water separation by chemical emulsion breaking and oil/water separation by dissolved air flotation (see Section 9.8.1). EPA proposed this technology basis because some existing SDD facilities use this technology and it projected significant reductions in conventional pollutants and determined that these reductions were cost reasonable.

Following proposal, EPA received comments and supporting data indicating that its estimates of current pollutant discharges from this subcategory were overestimated. In particular, commentors claimed that current discharges of oil and grease were minimal and that national regulation was not warranted for this subcategory.

For the final rule, EPA incorporated the additional information provided by commentors into its analysis. EPA continues to conclude that there are six direct discharging SDD facilities. However, EPA now concludes that direct discharges from these facilities

generally contain minimal levels of all pollutants. In particular, EPA's database indicates that regulation of oil and grease in direct discharges from SDD facilities is unwarranted because current oil and grease discharges from these facilities are not detectable (< 5 mg/L) or nearly not detectable. EPA has similarly determined that it should not establish nationally applicable limitations and standards for TSS because TSS discharges are, on average, minimal. The data show that TSS discharges may increase episodically, particularly when the dry dock is performing abrasive blasting operations cleaning. However, EPA has concluded that these episodic discharges from six facilities do not warrant national regulation.

Therefore, nationally applicable regulations for new and existing SDD direct dischargers are unnecessary at this time and these facilities will remain subject to permit limitations established on a case-by-case basis using BPJ.

9.9.2 PSES and PSNS

EPA proposed not to establish pretreatment standards for existing and new indirect dischargers in the SDD Subcategory based on the small number of facilities in this subcategory and on the small quantity of toxic pollutants removed by the technology options evaluated by EPA at proposal (i.e., less than 26 PE removed annually per facility (see 66 FR 471)). For the same reasons set out in the 2001 proposal, EPA is not promulgating pretreatment standards for existing or new indirect dischargers in this subcategory. These facilities remain subject to the General Pretreatment Standards (40 CFR 403) and local limits.

9.10 Summary of Technology Options Considered and Selected for the Final MP&M Rule

Table 9-1 summarizes all of the technology options considered for the MP&M subcategories for either the proposed or final rules. Table 9-2 summarizes EPA's selected technology bases for the final rule.

Table 9-1

Technology Options by Subcategory

Treatment or Source Reduction Technology	Technology Options Considered for the General Metals, Metal Finishing Job Shops, Printed Wiring Board, Steel Forming and Finishing, and Non-Chromium Anodizing Subcategories[a]							Technology Options Considered for the Oily Wastes, Shipbuilding Dry Dock, and Railroad Line Maintenance Subcategories[b]					
	1	2	2S	3	4	413 to 433 Upgrade	Local Limits to 433 Upgrade	5	6	7	8	9	10
Chemical Precipitation	✓	✓	✓	✓	✓	✓	✓						
Gravity Clarification for Metal Hydroxide Removal	✓	✓	✓			✓	✓						
Microfiltration for Metal Hydroxide Removal				✓	✓								
Chemical Emulsion Breaking Followed by Gravity Separation for Oil Removal	✓	✓	✓			✓	✓	✓	✓				
Ultrafiltration for Oil Removal				✓	✓					✓	✓		
Chemical Emulsion Breaking Followed by Dissolved Air Flotation for Oil Removal												✓	✓
Alkaline Chlorination for Cyanide Removal	✓	✓	✓	✓	✓	✓	✓						
Chemical Reduction of Hexavalent Chromium	✓	✓	✓	✓	✓	✓	✓						
Chelation Breaking/Precipitation to Remove Complexed Metals	✓	✓	✓	✓	✓	✓	✓						
Contract Hauling of Organic Solvent-Bearing Wastewater Instead of Discharge	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Countercurrent Cascade Rinsing to Conserve Water		✓	✓		✓				✓		✓		✓
Centrifugation of Painting Water Curtains to Extend Life		✓	✓		✓				✓		✓		✓
Centrifugation and Pasteurization of Machining Coolants to Extend Life		✓	✓		✓				✓		✓		✓
Sand Filter to Remove Additional Suspended Solids			✓										
Sludge Dewatering and Disposal	✓	✓	✓	✓	✓	✓	✓					✓	✓

[a]See Section 9.2.2 for a discussion of BCT options considered for the General Metals Subcategory.
[b]EPA evaluated Option 5 for the Oily Wastes Subcategory only, Option 6 for the Oily Wastes and Railroad Line Maintenance Subcategories only, and Options 9 and 10 for the Shipbuilding Dry Dock and Railroad Line Maintenance Subcategories only. See Sections 9.7.2, 9.8.2, and 9.9.1 for discussions of BCT options considered for these subcategories.

Table 9-2

Summary of Technology Bases for the Final Rule

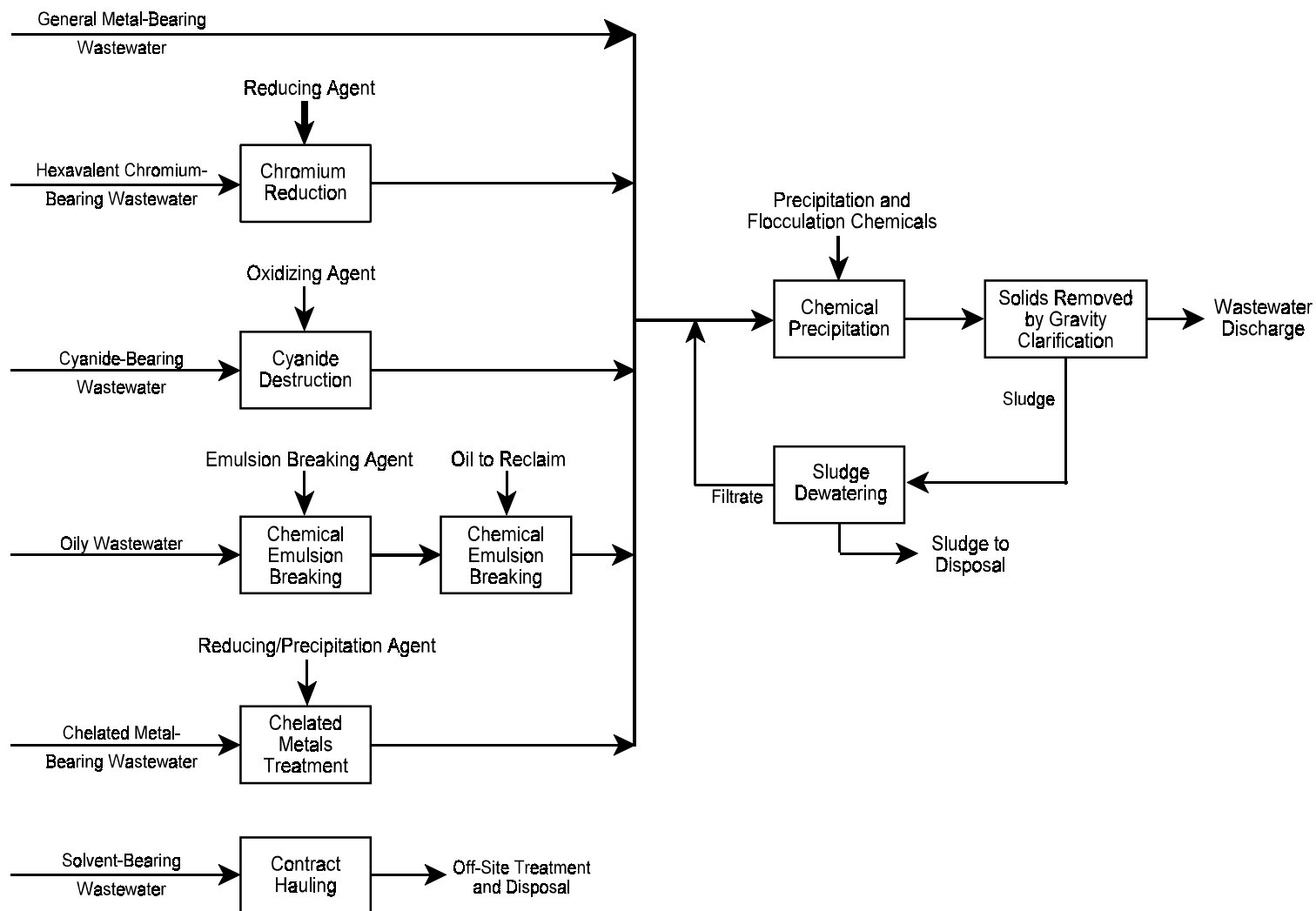| Subcategory	Regulatory Level	Technology Basis
General Metals	BPT/BCT/BAT/NSPS	No new or revised limitations or standards established
	PSES/PSNS	No new or revised standards established
Metal Finishing Job Shops	BPT/BCT/BAT/NSPS	No new or revised limitations or standards established
	PSES/PSNS	No new or revised standards established
Printed Wiring Board	BPT/BCT/BAT/NSPS	No new or revised limitations or standards established
	PSES/PSNS	No new or revised standards established
Non-Chromium Anodizing	BPT/BCT/BAT/NSPS	No new or revised limitations or standards established
	PSES/PSNS	No new or revised standards established
Steel Forming and Finishing	BPT/BCT/BAT/NSPS	No new or revised limitations or standards established
	PSES/PSNS	No new or revised standards established
Oily Wastes	BPT/BCT/NSPS	Option 6: In-process pollution prevention, recycling, and water conservation methods; and chemical emulsion breaking followed by oil/water separation
	BAT	No new or revised limitations established
	PSES/PSNS	No new or revised standards established
Railroad Line Maintenance	BPT/BCT/BAT/NSPS	No new or revised limitations or standards established
	PSES/PSNS	No new or revised standards established
Shipbuilding Dry Dock	BPT/BCT/BAT/NSPS	No new or revised limitations or standards established
	PSES/PSNS	No new or revised standards established

General Metal-Bearing
Wastewater

Reducing Agent

Hexavalent Chromium-
Bearing Wastewater

Chromium
Reduction

Oxidizing Agent

Cyanide-Bearing
Wastewater

Cyanide
Destruction

Precipitation and
Flocculation Chemicals

Chemical
Precipitation

Solids Removed
by Gravity
Clarification

Wastewater
Discharge

Sludge

Emulsion Breaking Agent

Oil to Reclaim

Oily Wastewater

Chemical
Emulsion
Breaking

Chemical
Emulsion
Breaking

Filtrate

Sludge
Dewatering

Sludge to
Disposal

Reducing/Precipitation Agent

Chelated Metal-
Bearing Wastewater

Chelated
Metals
Treatment

Solvent-Bearing
Wastewater

Contract
Hauling

Off-Site Treatment
and Disposal

Figure 9-1. End-of-Pipe Treatment Train for Options 1 and 2 Considered for the Following Subcategories: General Metals, Metal Finishing Job Shops, Non-Chromium Anodizing, Printed Wiring Board, and Steel Forming and Finishing
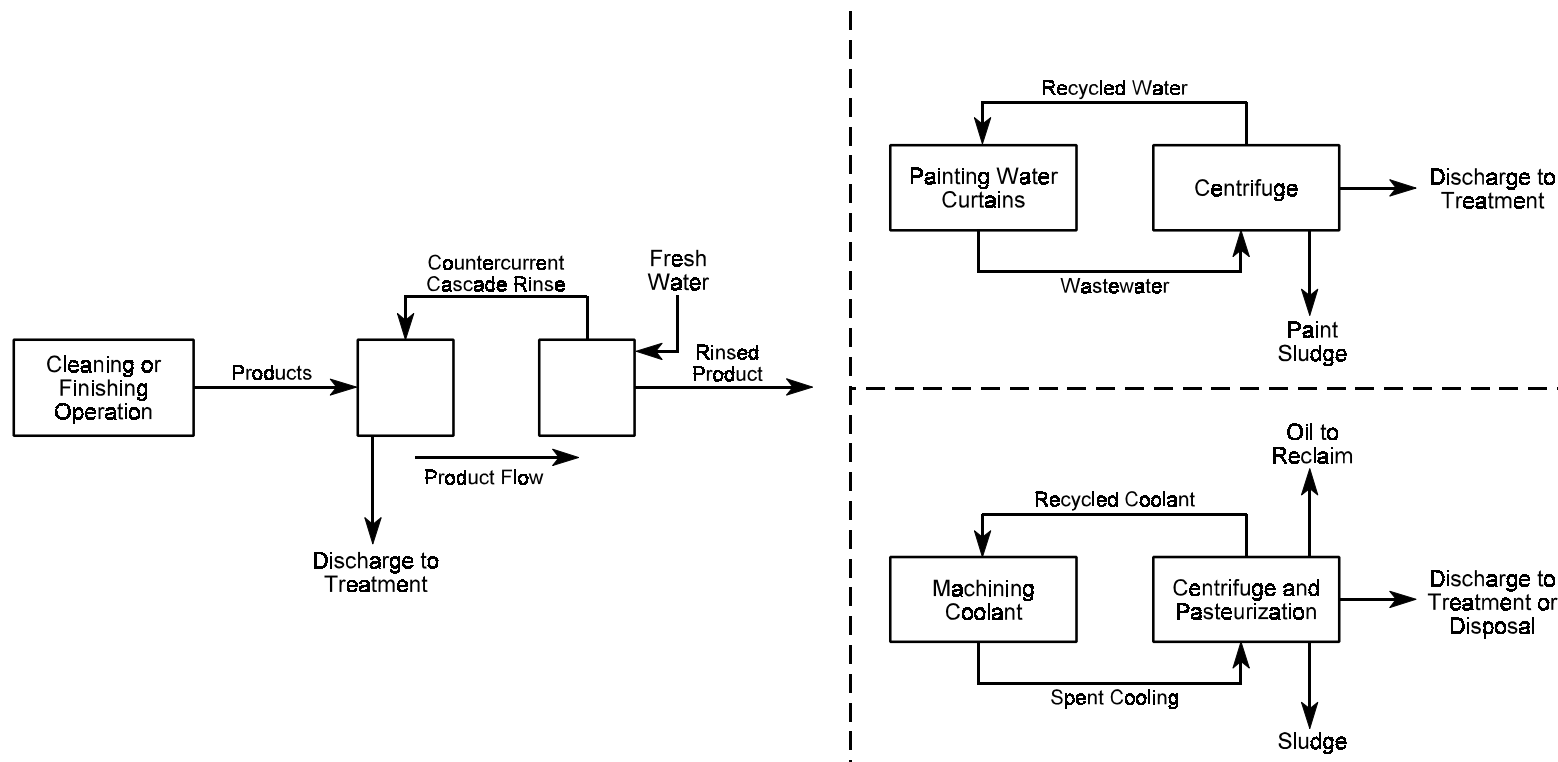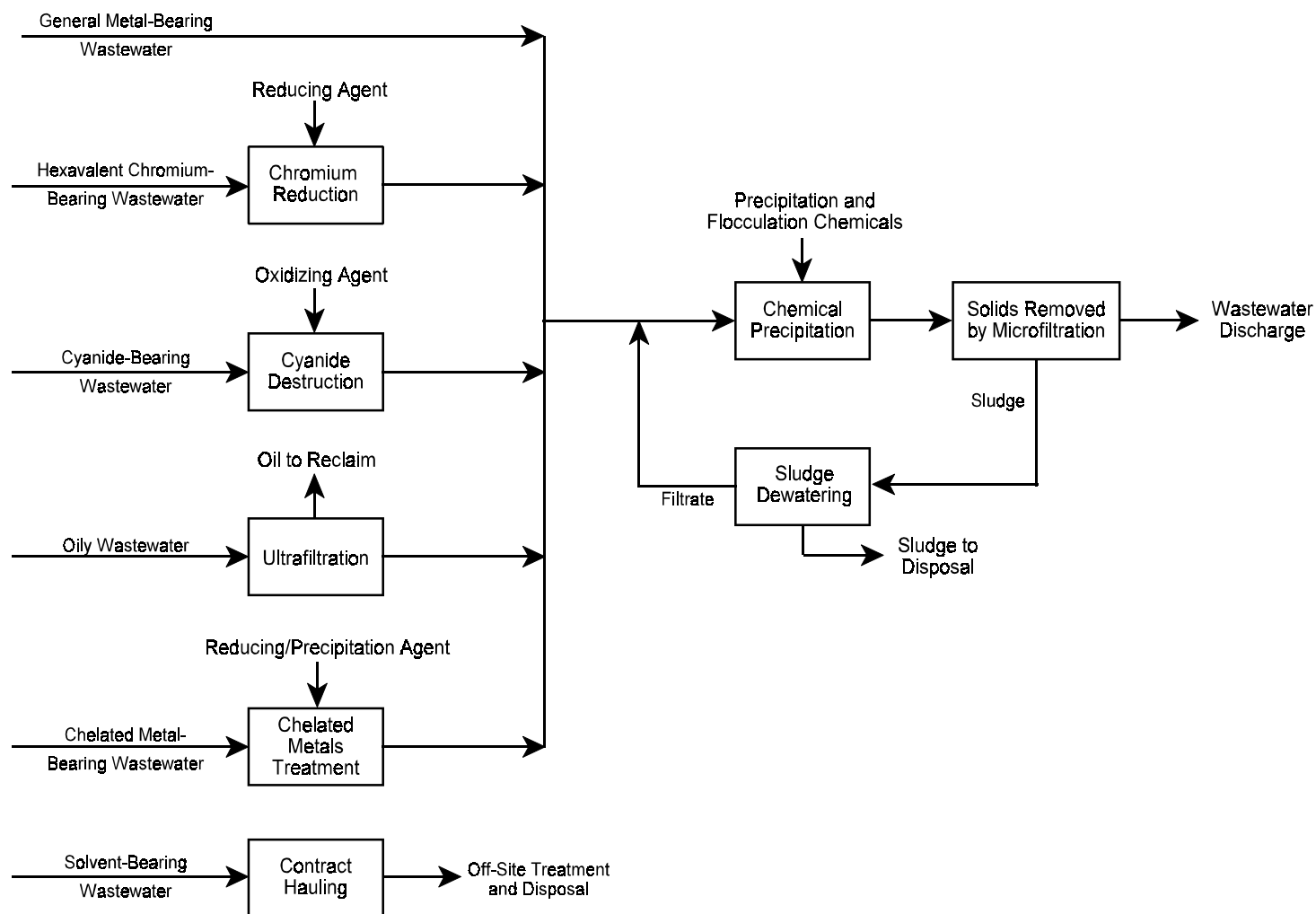
Figure 9-2. In-Process Water Use Reduction Technologies for Options 2 and 4 Considered for the Following Subcategories: General Metals, Metal Finishing Job Shops, Non-Chromium Anodizing, Printed Wiring Board, and Steel Forming and Finishing
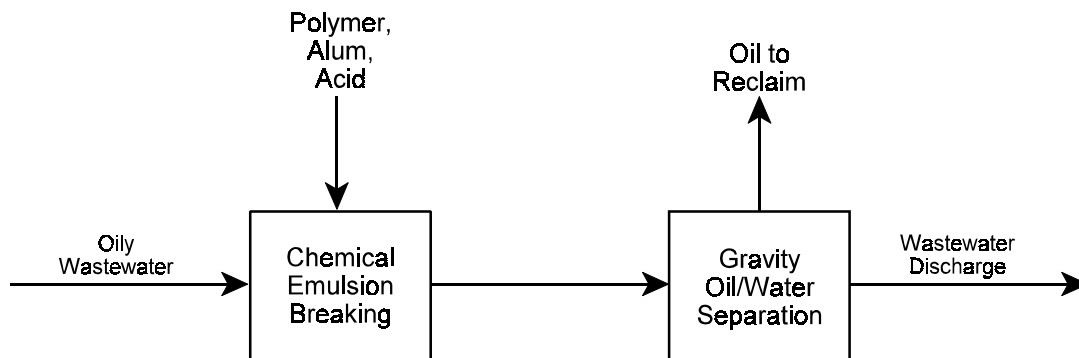
Figure 9-3. End-of-Pipe Treatment Train for Options 3 and 4 Considered for the Following Subcategories: General Metals, Metal Finishing Job Shops, Non-Chromium Anodizing, Printed Wiring Board, and Steel Forming and Finishing

**Figure 9-4. End-of-Pipe Treatment Train for Options 5 and 6 Considered for the
Following Subcategories: Oily Wastes and Railroad Line Maintenance**
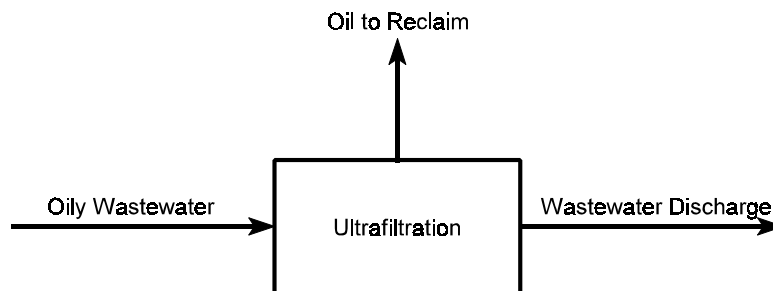

**Figure 9-5. End-of-Pipe Treatment Train for Option 7 and 8
Considered for the Following Subcategories: Oily Wastes,
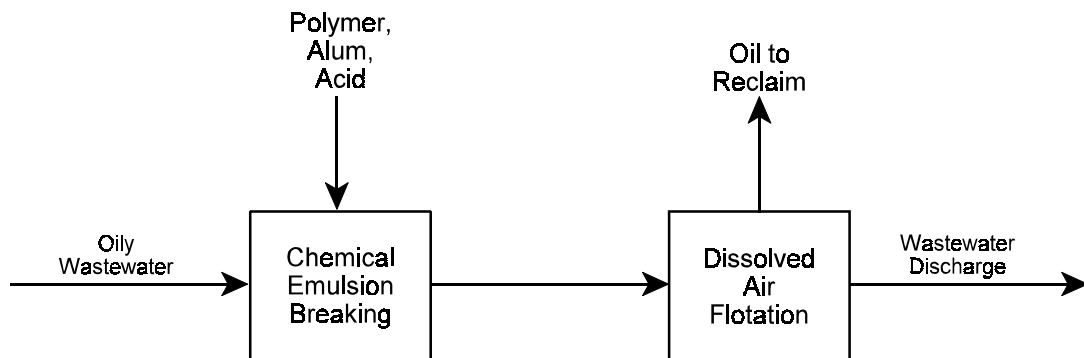Railroad Line Maintenance, Shipbuilding Dry Dock**

Figure 9-6. End-of-Pipe Treatment Train for Options 9 and 10 Considered for the Following Subcategories: Railroad Line Maintenance and Shipbuilding Dry Dock